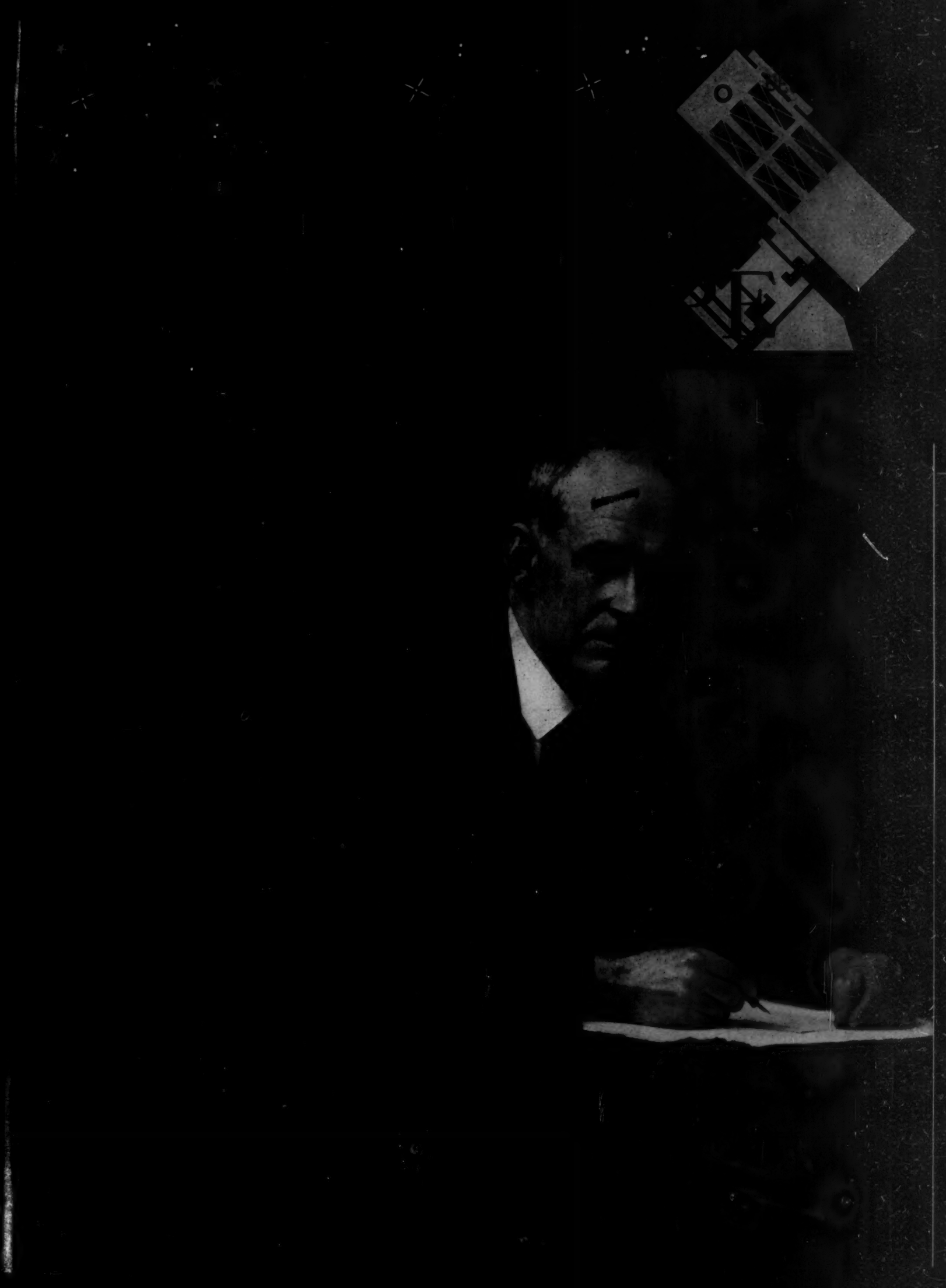

LETTER TO THE EDITOR

Sir:

I am sure you would be interested in a short account of the solar eclipse which occurred on Thursday, July 20, 1944. For a week earlier, the newspapers had played up the event and public interest in the celestial phenomenon was whetted. When the day came around all preparations had been complete. Film negatives, smoked glass, basins of water with a sober background to eliminate the glare, were all used. Even the naked eye, rather rashly, was pressed into service. Also all the schools and colleges let off their students for the occasion. Thus a nationwide interest was created. Crowds of workers, office and industrial, thronged open areas to regale themselves with the beautiful sight.

However, the eclipse was partial in Ceylon, being 61 per cent in magnitude at Colombo, the capital city. I am sending you a fairly accurate reproduction of the sun as it appeared during the course of the partial eclipse. At maximum, apparently less than 61/100 was obscured, which I am inclined to attribute to irradiation, causing a seeming enlargement of the illuminated area. This same effect is noticeable when the moon is just after or before the new phase, with the edges of the crescent extending beyond the dark disk.

During the eclipse, there were a few passing clouds. It was interesting to record the changing contours of the sun's image that was cast by a papaw plant on the floor of a room. As the shadows shortened with the elevation of the sun, the images changed from circles to "crescents" and back again to their original spherical shapes.

Your compatriots fighting in the jungles of Arakan in Burma must have enjoyed the gorgeous sight of the sun at central eclipse with an unobscured annulus ½ minute of arc wide.

Our Hindu neighbors in the subcontinent of India, over a hundred million of them, accord this event more than ordinary honours. Although Varahamihara, described as the greatest of Hindu astronomers, is credited with having in the 6th century A.D. explained eclipses scientifically, yet to countless hosts of his co-religionists then and now an eclipse was nothing more than the swallowing of the sun and the moon for a time by the celestial demons, Rahu and Ketu, since identified as the nodes, the former devouring the sun and the latter the moon.

As eclipses are supposed to be inauspicious, the faithful are enjoined to purify themselves by a bath at the commencement and another at the end of the event. An immersion in the waters of the holy Ganges is ordained as of special merit but to those unable to do so its purifying virtues are extended on this

(Continued on page 17)

Sky and TELESCOPE

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The Editors Note .

THANKSGIVING DAY brought a message for which this journal had good reason to give thanks, for the significance of our acceptance by a leading group of amateur and professional astronomers across the sea as well as for the increase in circulation involved. It was a wire message from the Astronomical Society of South Africa to the effect that a proposal to distribute **Sky and Telescope** to all members of the society had been adopted, with a present need for 120 copies monthly.

Part of the reason astronomy is so well developed as an international science is the nature of the subjects of observation — things celestial may be shared by observers everywhere. There are, however, many events in the sky which are quite different as seen or experienced in the Southern Hemisphere, and for one to be "astronomically international," he ought to be well aware of these differences and help spread his knowledge in his own neighborhood to contribute to international-mindedness.

For instance, right now, while your friends, who consider you the astronomer in their midst, want to know why the **latest** sunrise occurs on January 6th, instead of before Christmas (see Graphic Time Table, page 12), other amateurs below the equator are having to explain why the **earliest** sunrise does not coincide with the beginning of summer there last month!

The presence, in the tropics and southward, of many of our Servicemen who are amateur astronomers, the growth of internationalism, material arrangements such as this with our South African contemporaries; these are some reasons why **Sky and Telescope** will continue to carry material of value to readers all over the world, and, we hope, of considerable interest to those here at home.

Incidentally, if you are not preserving your issues of September, October, and/or November, 1944, we shall be glad to pay the postage for their return to us —the South African order has unexpectedly reduced our reserve supply.

VOL. IV, NO. 3 JANUARY, 1945
Whole Number 39

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BACK COVER: The region of Orion's sword, including the Great Nebula in Orion, photographed on a test plate with the Jewett Memorial telescope at the Oak Ridge station of Harvard Observatory. This is a Schmidt-type camera, the picture illustrates the relative shortness of the exposure as well as the fine quality of the images. The enlargement is four diameters from a portion near the edge of the original 8" x 8" plate, covering a field of about 25 square degrees. Compare the field of this picture with the entire constellation of Orion, as shown on page 7. Exposure time for the back cover was 30 minutes, in October, 1944; photograph by Bart J. Bok.

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He Expanded The Universe

By Harlow Shapley

Harvard College Observatory

Arthur Stanley Eddington (1882-1944)

"LET us look at the beta particle from its own point of view; it is just an ordinary electron in no way different from any other. 'But it is travelling unusually rapidly?' 'That,' says the electron, 'is a matter of opinion. So far as I am aware I am at rest . . . . In fact, I was just comtemplating with amazement *your* extraordinary speed of 100,000 miles a second with which you are shooting past me.' "

This segment of a discussion of a space-time frame "appropriate to an electron in self-contemplation" illustrates the ability of Sir Arthur Eddington to write with entertaining clarity on the deepest of scientific subjects. There are some who think deeply and report heavily; and others who report brilliantly but only about superficials. Whether he was working on atomic or stellar structure, on the motions of catalogued stars or unlisted galaxies, the curvature of space or scientific epistemology, Eddington could make clear the pathways he followed. That is why he was great as a leader as well as a contributor.

Few of his contributions lie fallow in the libraries. Nearly all of them incited followers and developers, and not a few of them inspired useful controversy. Most of Eddington's contributions may be grouped into four major fields: the motions of the stars, stellar interiors, relativity theory, and the philosophy of physical science. To handle these subjects adequately he had to be an astronomer, astrophysicist, mathematician, physicist (old style and new), and philosopher.

It is probably correct to say that during the past 25 years Eddington's influence on fellow astronomers has been greater than that of any other man. And outside the astronomical field his influence was not inconsiderable. His contributions in certain phases of modern physical theory were notable, and some were vigorously and usefully opposed by the physicists. The sincerity of his explorations along the boundaries between cosmogony, philosophy, and religion, also disturbed many formal professional philosophers but brought knowledge and inspiration to thousands who ponder philosophy and religion.

One generalization might well precede comments on his specific accomplishments. Eddington's powerful mind had a way of going out of bounds, of crossing the established frontiers of astronomy to investigate deep and challenging problems in other disciplines. The boundaries he transgressed have had a way of following him. Since his first scientific publication in 1906, the astronomical picture, except in limited fields such as formal celestial mechanics, has expanded almost beyond recognition, and Eddington, without telescope or experiment, has played a major role in expanding this universe.

After six years as chief assistant at the Royal Observatory at Greenwich, Eddington became Plumian professor of astronomy at Cambridge in 1913, the successor to Sir George Darwin. Later he also succeeded Sir Robert Ball as the director of the Observatory at Cambridge, where he lived until his death on November 21, 1944. He visited America for lectures in California, at Cornell, and elsewhere, and attended scientific meetings at home and abroad; also he attended those numerous ceremonies where various societies, universities, and academies honored themselves decorating him.

Here Dr. Eddington is shown chatting with Dr. Frank Schlesinger, of Yale, and Miss Annie J. Cannon, of Harvard. The occasion was the I.A.U. meeting in Paris in 1935.

The year after Eddington went to Cambridge he published the highly influential and now outdated book on stellar movements and the structure of the universe. In those ancient days (1914), in a diagram on page 31, Eddington placed the sun at the center of a slightly flat galaxy that was surrounded at a distance by an annulus of stars which composed the Milky Way. Twenty years later he commented on his early picture of the universe, somewhat startled that he and his contemporaries could have had such primitive notions. But the work of this English astronomer, following the ground-breaking by Kapteyn, led the way into the fertile study of star streaming (an almost obsolete term at present), and inspired observers and interpreters to build up the data that eventually led to our current concepts of galactic rotation. Those were the days before the globular star clusters had driven us toward the edge of our own galaxy and the Cepheid variables and novae had solved the cosmic significance of spiral nebulae and Magellanic Clouds. Nevertheless, many of the techniques developed and used by Eddington before 1914 were valuable tools for a later generation.

It was when Eddington boldly led us into the interiors of the stars, and isolated and emphasized the significance of radiation pressure in the maintenance of a luminous universe, that he first seriously transgressed conventional bounds. The astrophysics before then was largely the

physics of spectroscopy; after that time, we could no longer ignore quantum physics and nuclear structure.

Another great pioneering job, which before 1920 Eddington shared with De Sitter, was the exploration of the astronomical consequences of the Einstein theory. This time he widened the bounds of astronomy to include the rapidly developing relativistic cosmogony. Studies of the sources of stellar energy, and of the ages of the planets, suns, and galaxies, grew up under the inspiration of Eddington's keen investigation of space, time, and matter. With the active co-operation of the Astronomer Royal and his other English colleagues, Eddington led an eclipse expedition to Brazil in 1919 to make the first verification of one of the predictions of Einstein's theory —the bending of starlight in the sun's gravitational field. It was one of his few observational contributions.

From his work in the general theory of relativity, it was, of course, natural that an inquirer with Eddington's contemplative mind would move in the direction of epistemology. The relation to mind of matter, space-time, and the physical world generally, occupied much of his thoughts during the past decade. In this work he was not far from astronomy, or perhaps I should say cosmogony; nevertheless, in his metaphysical explorations he has left most of his astronomical contemporaries behind. Some will wonder if astronomy would not have been further advanced if instead of his *Philosophy of Physical Science*, the Tarner lectures of 1938, we had still more results of the application of the Eddington genius to the currently tough problems of astronomy and astrophysics. As this is written, however, a very important Eddington paper, "The Recession-Constant of the Galaxies," appears in *Monthly Notices* (see News Notes). This is possibly his last astronomical contribution—a worthy analysis and summation of an outstanding problem.

He was not too exclusively a scholar. On one visit to Harvard he divided his interests between galaxies and the Red Sox; and his conversation in his own home on the subject of cricket showed how he practiced relativity. A few of us were in his study in Cambridge, after the Stockholm meetings of the International Astronomical Union in 1938. It was a serious discussion about the embarrassing juxtaposition of giants and main-line stars in certain star clusters. There came a pause of exhaustion in the argument, and our host asked, "Then, perhaps that concludes the conference?" We nodded wonderingly as he stepped behind a screen and turned on the radio, remarking, "Just in time to get the cricket scores."

Wistfully, I note that the mystery of the juxtaposed giants and dwarfs—the problem of Sirius and its companion—still remains unsolved, while those cricket scores are probably long forgotten.

Quiet and friendly, Eddington was universally liked. He delighted the assistants in the Galactic Bureau at Harvard when on the occasion of an informal "tea" in his honor he accepted cup after cup of the domestic brew. I did not tell my collaborators that later he confessed that he nearly drowned himself with this American dilution in an attempt to get his quota of tannin!

Much of Eddington's earliest work has become, to be sure, obsolete, thanks to his own activities and the efforts of others. This is the fate of a pioneer who makes a scientific field sufficiently attractive to challenge contemporary investigators. His two major mathematical treatises, however, will long remain standards. They are *The Mathematical Theory of Relativity* (1923) and *The Internal Constitution of the Stars* (1926).

For the convenience of those who would like to check their Eddington collection, I should mention among his other books: *Stellar Movements and the Structure of the Universe* (1914); *Space, Time and Gravitation* (1920); *Stars and Atoms* (1927); *The Nature of the Physical World* (1928); *Science and the Unseen World* (1929); *The Expanding Universe* (1933); *New Pathways in Science* (1935); and *The Philosophy of Physical Science* (1938). Some of these volumes are easy reading, and all are skillfully written. The charming style of *Stars and Atoms*, for instance, has done much to create the present public interest in general science and the new cosmogony.

An informal snapshot of Dr. Eddington taken by Miss Cannon.

Along with Sir James Jeans, J. B. S. Haldane, and other English scientists, Eddington possessed the art of graphic analogy. Almost at random I choose the following cheerful excerpt from a discussion of the four-dimensional world of events, which through long habit we have too definitely divided into space and narrow intervals of time, forgetting the necessity of looking at the world as a whole. He notes ". . . the irrelevant stratification . . . which we have so unnecessarily introduced in our customary outlook. When this stratification is ignored we are enabled to see the processes in their simplest aspect, though not, of course, in their most familiar aspect. We must distinguish between simplicity and familiarity; a pig may be most familiar to us in the form of rashers, but the *unstratified* pig is a simpler object of study to the biologist who wishes to understand how the animal functions."

In the forthcoming problems of international scientific co-operation, immediately after the war, Eddington will be seriously missed. As president of the International Astronomical Union since 1938, he would have played a major role in the re-establishment of the activities and the spirit of good will in the various commissions of the Union. He was an ardent internationalist, and doubtless would have thought to round out his career by taking part in the construction of a permanent peace.

But perhaps Arthur Stanley Eddington might have always preferred to strive for significant beginnings than to attain dramatic conclusions. In one of his early lectures (1926) on the source of stellar energy, he said:

"I should have liked to close this course by leading up to some great climax. But perhaps it is more in accordance with the conditions of scientific progress that it should fizzle out, ending with a glimpse of the obscurity which marks the frontiers of present knowledge. I do not apologise for the lameness of my conclusion, for it is not a conclusion. I wish I could feel confident that it is even a beginning."

ASTRONOMICAL ANECDOTES

MORE FALSE PERSPECTIVE, OPTICAL AND VERBAL

LAST month, in the discussion of binocular eyepieces for telescopes, no mention was made of the fact that it is rather important to have provision, in such a device, for changing the inter-ocular distance. For an individual's telescope, used by him exclusively, or by him and a few friends, the device might prove suitable; for a public observatory, however, only a minority of those in line on a particular occasion will find it possible to look through both eyepieces simultaneously. It's tedious enough to get and keep a compromise focus for all comers, without the additional complication of changing the inter-ocular distance after every observer.

And, inevitably, there comes a time when one of the half-silvered surfaces buried deep in the vitals of the gadget begins to get stained or discolored; the binocular attachment is laid aside for attention some other day; everyone gets along all right without it, so it remains a relic of the days when we demanded more than was good for us.

There is a very interesting phenomenon in connection with stereoscopic vision that is illustrated here with a photograph taken from the May, 1933, issue of the *Journal* of the British Astronomical Association. If you have the notion that you can't be fooled into putting perspective into something where it doesn't exist, look at the picture. It was taken through a telescope, from a distance such that no perspective was visible to the unaided eye. The telescope naturally does not introduce any perspective, yet the eye, when it views what appears to be a close-up of the corner of the building, knows that perspective should be present. Because there is none, and the eye is violently resisted by the facts, the eye is deceived into seeing incorrect perspective: The parallel lines in the right side of the picture appear to diverge instead of converge.

That the same thing must be present in all telescopic views should be obvious. When the moon is magnified 500 diameters, there must be considerable distortion at the edges, of an involved kind not easily described, unless we say that every object at the moon's limb must appear larger than it really is. An object exactly at the center of the disk can now be thought of as appearing to be only 500 miles away, while objects at the limb are in reality 1,000 miles farther away than the object at the middle, yet now have been brought optically to essentially the same distance.

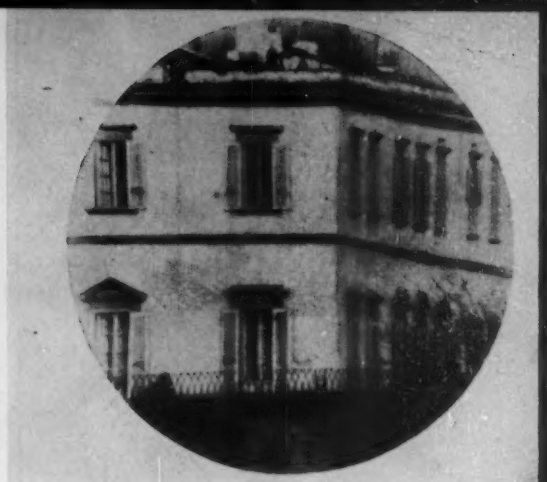
In the Adler Planetarium there is a magnificent large model of the moon; when it is viewed from a distance of 20 to 30 feet, something about it appears very different from a telescopic view, and it must be this effect of spurious perspective involuntarily experienced in telescopic views.

All of this emphasizes the foolishness of catering to the common desire of the public to demand, "How far away does this telescope make the moon appear to be?" The answer to this question should be a polite but firm insistence that the telescope does not make the moon appear nearer; the perspective is all wrong. The only thing the telescope does is to magnify the naked-eye image of the moon. Talk about magnifying powers of 10,000 diameters to be used on the 200-inch telescope, "thus bringing the moon up to only 24 miles from the earth," is probably the maximum in telescoptical absurdity.

We show ourselves much too timid in permitting incorrect notions to prevail, and even to become enlarged, in the public mind. We only smile and say, "Tsk, tsk," as we read some colossal nonsense published about astronomy, when we should, with full recognition of our responsibilities to science, put ourselves on record with its author that we don't approve of his particular brand of pseudo-interpretation. Of course, he will be very firm in stating that he has received no other complaint, and that is exactly the trouble with astronomers in the matter of public relations. They don't resent being misrepresented.

Unless astronomers assign themselves the task of stopping journalistic nonsense about astronomy, surely no one else is going to do the job. Errors are copied over and over, sometimes being perpetuated in cheap encyclopedias, because not one who calls himself a scientist has been willing to let his blood run warm for a while as he pens a "Letter to the Editor." We do have an obligation to those who follow us, and should keep the slate of popular impression clean as we go along.

R. K. M.



THE PERSPECTIVE OF A TELESCOPIC VIEW

Reproduced from the "Journal" of the British Astronomical Association.

AMERICAN ASTRONOMICAL SOCIETY TO MEET IN NEW YORK CITY

Upon the invitation of Professor Jan Schilt, director of the Rutherfurd Observatory, the American Astronomical Society will hold its 73rd meeting at Columbia University, New York City, on Tuesday, February 27th, and Wednesday, the 28th.

Registration of members begins, in Room 313 of the Pupin physics building, at 9:30 a.m. Tuesday. Sessions for papers will be held in Pupin 301 at 10:30 a.m. and 2:00 p.m., and again on Wednesday at 10:00 a.m. and 2:00 p.m. Specific assignment of the four sessions has not yet been made, but it is expected that one session will be devoted wholly to a symposium on double stars—in the broadest interpretation of that term. Another will be assigned to the Teachers' Conference, with Dr. Charles H. Smiley, of Brown University, in charge of the arrangement of that program.

The society dinner will be held at the Men's Faculty Club at 6:30 p.m., Tuesday evening.

The INDEX for Volume III

is now ready. Its style is similar to previous indexes, including title page, author, title, subject, and topic references. Inclusion of the whole number of each issue on each page of Volume III will facilitate use of this index. It is invaluable for quick reference and for best use of the volume. Send 25 cents, and your copy will be mailed immediately.

The Indexes for Volume I and Volume II are still available. Cost of these is 25 cents each.

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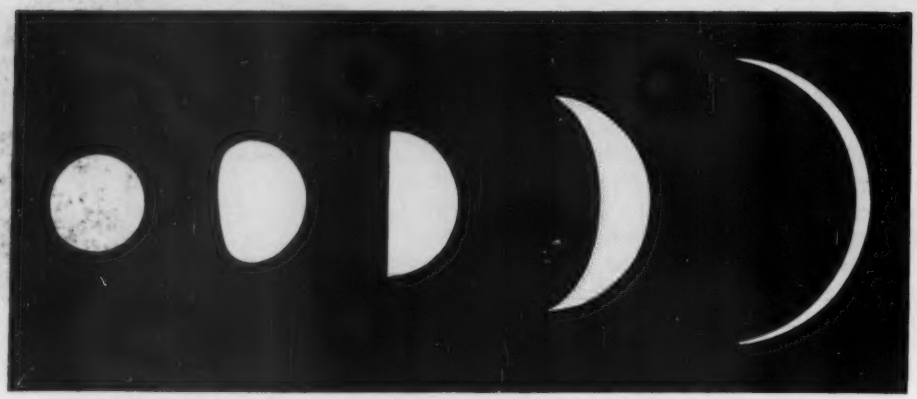


As it moves from the far to near side of its orbit, Venus undergoes changes in apparent size and phase, as seen telescopically. At greatest brilliance, it is a crescent.

Under the Winter Sky

By Marian Lockwood, *Hayden Planetarium*

Eastward beyond the region of the Bull
Stands great Orion; whoso kens not him in cloudless night
Gleaming aloft, shall cast his eyes in vain
To find a brighter sign in all the heaven.

IN THESE days when the science of navigation is playing such a large part in the economy of the war, stars have become of greater importance than ever before. We are now a star-conscious world, for our navigators as well as those of our allies and our enemies are finding their way in the air and on the sea by means of those beautiful sparkling bits of silver shining overhead. Across the evening skies of winter parade many of the more important stars used in navigation. Here, too, we find striking constellation figures, with multitudes of stars and nebulae which are fascinatingly beautiful in themselves. While summer evenings are on the whole more comfortable for stargazing, the observer forgets the cold of winter nights in the glorious array of brilliant constellations which pass before him across the middle regions of the sky, high enough to escape the doubts and mists of the horizon.

During the clear cold evenings of January, 1945, the queen of all the planets, Venus, bestows her gift of beauty on the pastel-colored west. Increasing in brilliance nightly during this entire month — in fact, until March 10th — Venus moves steadily eastward, widening the space between her and the sun. By the middle of the month the planet sets a couple of hours after the sun goes down. Those amateur stargazers who own either good opera glasses or binoculars have an excellent opportunity during these coming weeks to watch the changes occurring in the phases of Venus as it swings toward the earth, lengthening and thinning out into a magnificent and graceful crescent. Venus and Mercury alone among the planets exhibit a whole cycle of phases as does the moon. The observer, watching the intense sunlight reflected from the white clouds surrounding and hiding Venus herself, may reflect that by those very clouds which give her light and splendor in our eyes, the surface of Venus is kept in eternal shadow.

While her brother planets cannot claim Venus' spectacular beauty, both Jupiter and Saturn play their parts this month in adorning the blue-and-silver tapestry of the sky. Saturn is in Gemini, as it is during this entire year, and is visible when dark sets in. Jupiter, shining with lucid brilliance, rises about midnight and reaches the meridian at dawn.

January is the month when Orion, that splendid prince of the heavens, dominates the starry kingdom from sunset to sunrise. Some authorities believe that Orion's name originated in the valley of the Euphrates thousands of years ago, possibly stemming from the Akkadian word Uru-anna, a name which was sometimes also applied to the sun, and which meant *the Light of Heaven.* It is an appropriate name, for no group of stars can compare with Orion in beauty and brilliance. Orion is equally well known in Northern and Southern Hemispheres since the top star of his belt lies almost exactly on the celestial equator, thus placing him half in one hemisphere of the sky and half in the other. From a position at the north pole one would see the upper half of the giant's body, while from the south pole the lower half of his body would be visible.

Hundreds of myths are associated with the figure of the Hunter. Perhaps the one most commonly known is that connected with the constellation Scorpius. Just as Orion dominates the winter sky, so Scorpius rules the heavens in the summer season. According to the traditional story, Orion ceaselessly vaunted his strength and power, and never tired of boasting that not even the gods could lay him low. The gods, at last, angered by his taunts, ordered the Scorpion to sting Orion in the heel. Later, when giant and scorpion were elevated to a place among the stars, Orion found himself halfway around the sky from the Scorpion. And that is why, or so they say, Orion disappears in the west as the Scorpion rises in the east. According to the great Greek poet Aratos, "When the Scorpion comes, Orion flies to utmost end of Earth."

Orion comes to the meridian during the first half of January an hour or so before midnight. He can easily be recognized by the four bright stars which form a striking rectangle, and by the diagonal of three 2nd-magnitude stars which mark his belt. The star in the right shoulder is Betelgeuse, a name derived from the Arabic words meaning *the armpit of the Central One.* Orion is obviously called the Central One because of his position in relation to the celestial equator. Betelgeuse is Alpha Orionis in spite of the fact that it is not as bright as Rigel (marking the left foot) which is designated Beta. Both are brighter than standard 1st-magnitude stars.

Betelgeuse is a variable, changing in brilliance from magnitude 0.5 to 1.1 over an irregular period. Betelgeuse has the distinction of being the first star to have had its angular diameter measured. The instrument used in this famous measurement in December, 1920, was the Mount Wilson interferometer. Today Betelgeuse, an orange-red star, ranks as one of the largest known, although its diameter is thought now to be less than that of some other red giant stars. If one can imagine the sun placed at the center of Betelgeuse, with Mars revolving around the sun in its accustomed orbit, the red planet would still be some distance below the surface of the star. This will give you a more graphic idea of the star's size when you recall that Mars' mean distance from the sun is more than 140 million miles.

Rigel is the star diagonally across the rectangle from Betelgeuse. It is an intensely beautiful and brilliant

object, bluish white in color. It is one of the more remote of the brighter stars as seen from the earth, approximately 550 light-years distant. Rigel has a companion star which can be seen as such through a 3-inch telescope.

Delta, otherwise known as Mintaka, is the top star in the belt, located almost on the celestial equator. A double star, it can be separated into its two components with a good pair of binoculars having a magnifying power of 10 times.

Hanging from the belt of Orion are several fainter stars which traditionally mark the giant's sword. Around Theta, one of these stars, there is found one of the most magnificent of all celestial sights, the Great Nebula in Orion. As its name accurately indicates, the Great Nebula is an extensive mass of thin and tenuous gas, just barely visible to the naked eye. It was apparently first noticed in the early part of the 17th century and has been a favorite object for professional and amateur astronomers ever since. The Great Nebula boasts a mass at least 10,000 times that of the sun.

Tennyson wrote of Theta and the surrounding nebula as follows:

A single misty star
Which is the second in a line of stars
That seem a sword beneath a belt of three.

The nebula is green in color and is an interesting object for good binoculars or small telescopes, as well as for larger instruments.

Orion contains more brilliant stars than any other constellation—two of the 1st magnitude, five of the 2nd, three of the 3rd, 14 of the 4th magnitude, and numerous fainter stars which yet add to the total beauty of the pattern.

By following the line of the three stars in Orion's belt, a line three degrees in length, we come, by traveling westward, to the star Aldebaran, the orange-red star marking the eye of Taurus, the Bull. Aldebaran forms the left top of a clearly marked V. The other stars in this V comprise the open or galactic cluster known as the Hyades, relatives of the Pleiades, another open star cluster farther west and in the Bull's shoulder.

Using Orion further as a guide group to other constellations, we follow the line of the belt eastward to the brilliant blue-white star Sirius, known also as the Dog Star. This nickname probably originated from the fact that Sirius performed for the ancient Egyptians a warning function, since for long periods its heliacal rising occurred almost simultaneously with the annual overflowing of the Nile. Sirius is one of the nearer stars, approximately 50 trillion miles from the earth. In actual brilliance, if it were placed at the same distance from the earth as is the sun, it would outshine the sun by more than 25 times. If Sirius had happened to be *our* star, instead of the sun, probably no life would be possible on the earth because of the vast amount of energy given out by Sirius.

Directly beneath the feet of Orion crouches the Hare, Lepus, a constellation with an interesting design—as you can see from a star map. It is of small importance astronomically, though famous for a blood-red 6th-magnitude star which shines within it.

By drawing a line from Saiph in Orion's right knee, through the lower

(Continued on page 11)

This picture shows the principal parts of Orion, as photographed on blue-sensitive plates; thus red Betelgeuse appears faint. Compare the region of the Great Nebula with the back cover, where south is at the top.

NEWS NOTES

By Dorrit Hoffleit

ECLIPSED SUN FOR EARTH SURVEYORS

The Committee for the Distribution of Astronomical Literature brings us abstracts, including two papers reproduced in full, on the work planned by Scandinavian and Finnish astronomers for the total solar eclipse of July 9th. The total eclipse will begin at $12^h\ 13^m.8$ Universal time, at longitude 115° 57′ W., 44° 23′ N., in Idaho, travel northeastward over Canada, Hudson Bay and Greenland; thence it will cross Norway, Sweden, Finland, and move over the U.S.S.R., ending at $14^h\ 40^m.9$, at longitude 72° 33′ E., 41° 43′ N., in southern Russia near Tashkent. The greatest duration of totality is over 75 seconds in the region of the east Greenland coast; in Sweden and Finland, it will last about 70 to 59 seconds.

Professor Bertil Lindblad, of the Stockholm Observatory, outlines numerous problems to be investigated. They are largely astrophysical, dealing with the flash spectrum and polarization of the light of the corona. Of particular interest, however, are plans for astronomical-geodetic work involving international co-operation and necessitating accurate observations all along the path of totality.

In 1928, the Polish astronomer, T. Banachiewitz, pointed out that the times of contact at the 1927 eclipse in Lapland, recorded by moving picture devices, could be ascertained to within 0.04 second. Such high accuracy, according to Professor Ilmari Bonsdorff, of Finland, justifies observations of solar eclipses for the purpose of determining the distances between two widely separated points on the earth which are on the path of totality. The problem is one of triangulation, the third point of the triangle being the moon. The coming eclipse offers an opportunity for an accurate determination of the distance between points in Canada, Greenland, and Europe. To be worthwhile for studies of the shape of the earth (geoid) the distances should be found to an accuracy of 60 meters.

This accuracy requires fairly delicate measurements which encounter three fundamental sources for error: 1. Uncertainties in the moon constants which determine the position and motion of the moon, the chief uncertainty being in the mean parallax of the moon. 2. The topography of the moon, the times of observed contact depending on whether the exact point observed or measured on a plate corresponds to a high lunar mountain or to a valley. 3. The errors of the time-recording instruments themselves. Considering all these sources of error, Professor Bonsdorff finds that the desired distance can be ascertained to within 35 meters, a result possible because of the large number of exposures available from the cinematographic method. Assuming 6,000 meters as the difference in elevation at the limb of the moon, each time of contact is effectively about six seconds (different points along the limb eclipsing at every instant) within which period some 300 photographs are obtained.

For direct photography using this method, a long-focus telescope is essential, however, in order to obtain sufficiently large images. There is some handicap, then, because of the blurred images caused by the motion of the moon, as well as the usual atmospheric unsteadiness. Nevertheless, the required accuracy is still attainable.

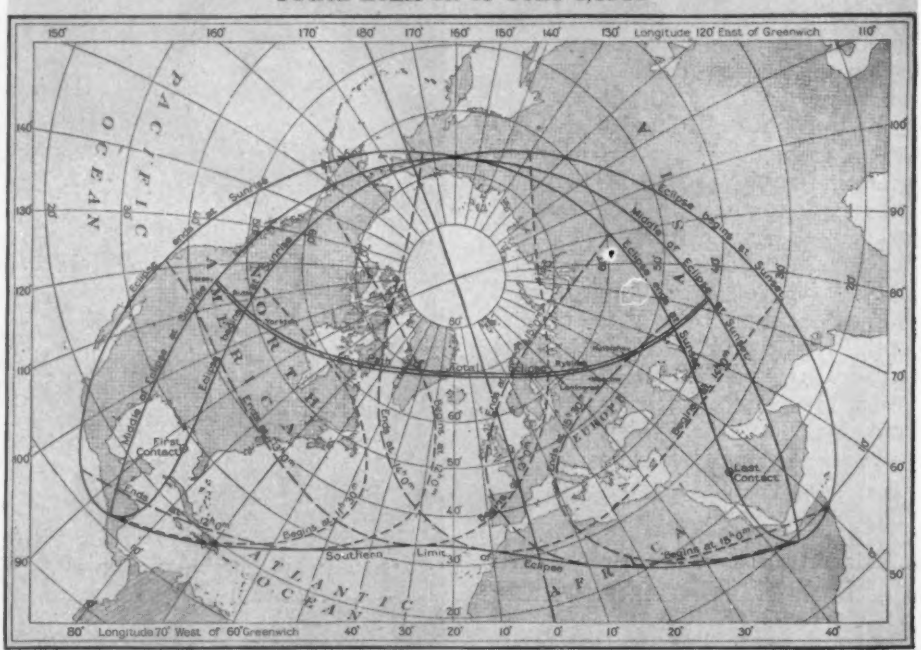
Professor Lindblad, on the other hand, offers further modification of this method to increase its accuracy and to make the determination of which exposure represents contact an exact procedure. If, instead of direct photographs, movies are taken of the spectrum of the sun at the times of the inner contacts (second and third, beginning and end of totality), smaller, objective-prism cameras can be used. Atmospheric disturbances are less important now, since the changes in the appearance of the spectrum depend only on the relative positions of the sun and the moon. As the moon covers the sun's photosphere, the predominant spectrum changes from the continuous spectrum of the solar disk to the bright-line emission of the reversing layer. The change takes place very abruptly, so that a definite time can be established at which complete covering (or uncovering) of the photosphere takes place. Successful pictures of this type have already been obtained at the 1927 eclipse, using a camera of 10 inches focal length. For the direct method, Professor Bonsdorff mentioned a telescope of about 100 feet focal length.

With the recent (pre-war) developments in coronagraphs and the like, we feared that solar eclipse expeditions would soon become astronomically non-essential. Apparently the usefulness of this beautiful spectacle of nature has not yet been exhaustively explored.

SOVIET SCIENTISTS PLAN ECLIPSE EXPEDITIONS

The eclipse of the sun will possibly be observed by more expeditions in Russia than anywhere else, for a wire message recently received directly from G. Fesenkov, chairman of the 1945 Eclipse Commission, tells of 22 expeditions being planned, probably with 100 "specialists" and 70 junior scientists making up their personnel. Toward the end of May, they will set

TOTAL ECLIPSE OF JULY 9, 1945



Note - The hours of beginning and ending are expressed in Universal Time or Greenwich Civil Time.

Reproduced from the "American Ephemeris and Nautical Almanac."

up observing stations at Serdobol, Babyevo, in the Gorky region, the Uralsk region, and in many other places.

The message tells of some of the results of Russian observations of the eclipse of September 21, 1941, when seven expeditions observed, mostly with Russian-made instruments. The temperature of the sun's atmosphere, the relativity displacement of stars near the sun's limb, and the temperature of the corona are among the items to be checked. Several cameras of five meters focal length will be located at various points along the path of totality. A stratosphere flight is also planned, presumably by airplane, in the event of bad weather.

BOMBS AND THE WEATHER

Popular Astronomy quotes from the London *Evening Standard* on "How Bombs May Affect the Weather." It has been observed that the explosion of a flying bomb in air was accompanied by a sudden but small rise in the barometric pressure. Under favorable conditions, pressure waves of this sort might cause slight local weather abnormalities.

"Violent explosions at cloud level could cause very slight local rainfall by furnishing through the small explosive particles, numerous nuclei of condensation, or by causing myriads of cloud particles to coalesce. Clouds, already forming, might be speeded up in the process by convectional currents set up around the core of the explosion."

Any effects would be purely local, however, and they would occur only in case the weather and cloud conditions were just right to begin with.

THE VELOCITY OF LIGHT—AN ACCURATE CONSTANT

"Light travels at a speed of 186,000 miles a second." This statement, remembered by rote from school days, we are apt to take for granted. How accurate is the figure used, and is it really constant? Dr. N. Ernest Dorsey, of the National Bureau of Standards, has examined critically all available direct determinations of the velocity of light, from Fizeau's work in 1849 to investigations as late as 1940. The full discussion is given in Volume 34 of the *Transactions* of the American Philosophical Society, while an abstract is found in the *Monthly Astronomical News Letter* for November.

Eliminating the early results which are subject to large and undetermined instrumental errors, Dorsey finds that the velocity of light in a vacuum is 299,773 kilometers per second, or 186,270 miles per second, with an uncertainty of less than 10 kilometers per second, or one part in 30,000. Moreover, there are no experimental data that give any evidence of secular variation in the velocity of light within the measurable accuracy, and it remains as "constant" as ever.

THE LARGE AND THE SMALL FOR EDDINGTON'S AGE OF THE UNIVERSE

Astronomy was once considered a subject dealing with very large bodies and vastly great distances. This is still true, but not exclusively. Modern astrophysics deals to a considerable extent with the very smallest constituents of the universe: atoms, protons, and electrons. The successful interpretation of stellar spectra, from which, for example, temperatures, absolute magnitudes and other physical characteristics of the stars are "read," depends very appreciably on a knowledge of how these sub-microscopic components of stellar atmospheres and stellar interiors behave. The solution of cosmological problems is likewise intimately dependent on modern atomic physics.

This dependence is readily apparent in one of the late Sir Arthur Eddington's contributions, "The Recession-Constant of the Galaxies," published in the *Monthly Notices* of the Royal Astronomical Society, received since the news of the author's decease. In this paper, in which the constants of physics play a heavy role, it is found that "the former vague description of past time as logarithmically infinite is superseded by a definite upper limit of 90,000 million years."

The discussion summarizes and brings up to date Eddington's classical investigations on this topic; these started with Weyl's suggestion in 1919 of a theoretical relation connecting the size of the universe with the fundamental constants of atomic physics. Most important of these constants appeared to be the ratio of the "electrical radius" to the "gravitational radius" of the electron. This ratio (4×10^{42}) Eddington thought must somehow be related to the number, N, of elementary particles in the universe. Later, seeing no reason for preferring electrons, he found that the corresponding proton constants yielded a size for the universe which was obviously too small, while the electron constants gave a size now known to be too large.

Therefore, to avoid bias, Eddington more recently adopted as the most fundamental constant the ratio of the electrical to the gravitational force between a proton and an electron, 2.3×10^{39}, which he calls the *force ratio*. Meanwhile, in 1930, the mass of the universe had been fairly well determined from measurements of the recession of extragalactic nebulae and the application of the Friedmann-Lemaitre theory of the expanding universe. The mass found was such that the square root of N was 5.3×10^{39}, a number remarkable for its similarity to the force ratio. "Astronomical observation had, by establishing this agreement," says Eddington, "given a clue which must certainly lead to a great unification of physical theory."

From the work of Hubble and Humason at Mount Wilson Observatory, data are available on the recessional velocities of galaxies in a fairly large volume of space; also, it is indicated that the galaxies can be considered as having large-scale uniformity of distribution (there being local irregularities here and there). A "laboratory value" for the rate of expansion for a universe of infinite dimensions is established, by three independent methods, as being 572.4 kilometers per second per megaparsec. (A megaparsec is a million parsecs, or 3,250,000 light-years.)

The rate of expansion, however, increases with the size of the universe. If its radius were only some 600 megaparsecs, the recession would be slightly more than 400 kilometers per second per megaparsec. Hubble and Humason find an observed value of 560, that is, they find that for each increase of a million parsecs in the distance of a galaxy, there is a shift of its spectrum toward the red corresponding to a Doppler effect of 560 kilometers per second. As Eddington points out, there is considerable uncertainty in this figure, but he thinks we must adopt a value greater than 490. This gives a radius of at least 900 million parsecs for the universe; and the observed value of 560 corresponds to a radius of some 2,400 million parsecs.

If various values for the radius of the universe are assumed, its total mass being known already as 1.977×10^{33} grams (or 10^{22} solar masses), it is possible to calculate what densities should exist for the corresponding radii. Then, comparing observed densities (galaxies per unit of space) with these computed values gives another way of arriving at the present size of the universe. Shapley estimates five or six galaxies per cubic megaparsec, while Hubble's estimate is 10, the galaxies averaging about

(Continued on page 17)

Sirius, the brightest star in the sky, is situated in the constellation of Canis Major. Its light takes more than eight years to reach us, yet even at that distance this star's gravitational pull on the earth is considerable.

So Little—So Big!

By Carl A. Richmond

HOW strong is the gravitational pull between our earth and a representative neighboring star? As such a star, consider Sirius. Except for members of our solar system, it appears as the brightest object in the sky. Moreover, it is comparatively near to us; beyond the planets and nearer than Sirius, there are not half a dozen objects which even attain naked-eye visibility. Sirius can be seen at one hour or another from most places of human habitation, so it is a good example by which to make our question definite: What is the pull between the earth and Sirius?

Before we arrive at an approximate answer, make a guess. A consideration to influence your guess is that gravitation is a feeble force compared with other familiar forces. You can hold in the hollow of your hand all the apparatus to demonstrate the force of elastic deformation, or capillary attraction, or magnetism, not to mention other kinds of force. But to demonstrate gravitational force within the space between the floor and ceiling of a laboratory is a matter of considerable difficulty and delicacy.

It is true that if you drop a flask on the floor, you are demonstrating gravitational force, but the whole earth beneath the floor has a part in that demonstration. Two solid lead spheres, each a ton mass, side by side, and as near together as may be without touching, exert a gravitational pull on one another which is less than the breaking strength of a spider filament. If they were separated to the distance between the earth and Sirius, the pull between them would be very much less. Indeed the pull decreases, not in proportion to the distance, but in proportion to the square of the distance. Every time the distance doubles, the force of the pull quarters. And Sirius is so far distant from the earth that if an intending visitor to the earth had started from there at the birth of Christ, coming as fast as the fastest airplane, he would not yet have come a thousandth part of the way. A feeble force to begin with, is gravitation, and much weakened by distance—says the advocate of a low guess in discussion of our opening question.

But there are considerations *contra*. The lead spheres are extremely small when compared with our earth, and smaller yet when compared with Sirius. Though the pull between the two lead spheres, near together, would not break a spider web, the pull between one of them and the earth beneath it is exactly one ton weight; this is in spite of the greater distance between centers, 4,000 miles instead of about two feet. Evidently the bigness of one or both of the attracting bodies may be a powerful factor to counteract the intrinsic feebleness of the gravitational force and its further enfeeblement by distance.

It is time to stop toying with our problem and to solve it. To compute the answer is an easy task.

We begin with the simple fact that the earth pull on a ton mass at a distance of one earth radius from the earth's center is one ton weight.[1] If the mass of Sirius is M tons, and if that mass could be put in the place of the ton mass, the pull would be M tons of weight pull. But Sirius is farther away; let its distance in earth radii be D. Those hypothetical M tons of weight pull must be divided by D × D to get the actual pull. The number of tons of pull which will answer our question is given by the formula M/D^2. How many tons mass are there in Sirius? And how many times the earth radius is the distance to Sirius? When we know the answers to these questions, we shall know M and D, and be in position to write down the answer to our main question.

Fortunately for the prosecution of this inquiry, Sirius is a double star; therefore, as explained in astronomy textbooks, its total mass can be computed, and the mass of Sirius and its companion is known to be about 3.2 times the mass of our sun. Also, in any such book, we learn that the mass of the sun is about 332,000 times the mass of our earth, and that the earth's mass is about 6.6×10^{21} tons. (If this notation is unfamiliar, it is easily explained: 10^{21} is short for 1,000,000,000,000,000,000,000. The exponent 21 tells the number of ciphers following the 1. We shall use this notation henceforth. Also, let the word "about" be understood with all our big numbers; they are all rough approximations.) Therefore the mass of Sirius is $3.2 \times 3.32 \times 10^5 \times 6.6 \times 10^{21}$ tons, which is easily worked out

[1] A ton weight is equal to 2,000 pounds weight, which in turn is equal to nearly 65,000 poundals, the unit of force in the foot-pound-second system. The ton weight also equals 8.8964×10^8 dynes, the unit of force in the centimeter-gram-second system.—ED.

to be 7.0×10^{27} tons; a prodigiously big number of tons. But this number is hypothetical, the hypothesis being that the mass of Sirius has been put in place of a ton mass at the earth's surface. Wait and see what will happen to this big number when it is divided by D^2.

From the same astronomy textbook, we may learn that the distance to Sirius is about 8.6 light-years. It is well known that the light-second is 186,000 miles, which is about 46.6 earth radii. To get the number of earth radii in a light-year, we must multiply 46.6 by the number of seconds in a year; that is, we must multiply 46.6 by $365 \times 24 \times 60 \times 60$. The result is 1.47×10^9, the number of earth radii in the distance light travels in a year. The distance to Sirius is 8.6 times as great; that is 1.26×10^{10} earth radii. This is the number D. Its square, D^2, is therefore 1.6×10^{20}; and this is the number by which M, already ascertained to be 7.0×10^{27} tons, is to be divided. The division gives us 4.4×10^7 tons, that is, 44 million tons.[2] This seems like a very big pull between objects so far apart as our earth and Sirius. It is bigger than I, for one, expected. Though it is the answer to our question, it does not register in my mind. It may be childish, but I ask, "How much is a pull of 44 million tons?" As a muscular effort, I cannot hope to feel it. Can I see it, in any fair sense of the words? How thick must a steel wire cable be to sustain it.

A prudent factor of safety is transgressed if we load a good steel cable one inch in diameter with 50 tons. Two cables are loaded to correspond with their strength, when the loads are in proportion to the squares of their diameters. Let x stand for the unknown diameter of the cable which will sustain a pull equal to that between the earth and Sirius. Then our proportion is $50 : 44{,}000{,}000 = 1^2 : x^2$, whence x equals about 940 inches, that is, over 78 feet. This is 22 times the diameter and almost 500 times the cross-section of the thickest suspension bridge cable. If there is any man-made unitary structure which sustains as great a tension as this supposed 78-foot steel cable, it is unknown to me. All the locomotives in the world pulling together could not match this pull between Sirius and our earth.

But, astronomically, is that a very big pull? We measure a force by what it can do. The effect of a continued pull on a free body is to accelerate it in the direction of the pull. If I stand on the bank of a pond and pull on a rope attached to a boat afloat and at rest, it begins to move toward me, and, within limits, the longer I continue the pull, the faster moves the boat. For a rowboat, this effect is readily perceptible. But suppose I stand on a pier with the bow of a great ship like the *Queen Mary* toward me, from which a rope is passed to me. I give it a turn about my hips, and brace my legs at 45 degrees against a cleat underfoot, and pull as much as I am able with continued effort. Assuming no complication, as of wind or wave, how long must I pull like this to bring the *Queen Mary* to a velocity of one inch per minute? The answer is—about half a minute. The computation is elementary and easy, based on the simple relation that, when expressed in consistent units, the acceleration is equal to the force divided by the mass, the force in this case being about 150 pounds weight (150×32.2 poundals), and the mass about 50,000 tons.

If that is what I can do to the *Queen Mary* pulling half a minute by a clothesline, what can Sirius do to our earth, pulling at the limit of strength of a steel cable 78 feet in diameter? Whatever this effect, it will be superposed on the other motions of the earth, especially the motion of its circuit around the sun. The answer to the question at the beginning of this paragraph is that to build up the same inch-a-minute velocity that I am supposed to build up by a half-minute pull on the big ship, Sirius must pull on the earth and keep pulling for nearly 200 years. Of course, all other stars in the sky are pulling us, too, from as many directions.

When in the winter night sky you catch sight of Orion near the meridian, face south and follow to your left along the line of the three stars of his belt about six or seven times as far as the distance along those three stars. There you should see the brilliant star Sirius, toward which the earth under your feet is impelled by a pull so mighty that it would almost if not quite break a steel cable 78 feet in diameter; a pull so mighty, and at the same time so feeble that in 200 years it sets the earth a-moving only an inch a minute.

[2]The energetic reader may verify the author's results by using Newton's general law of gravitation: $F = G \frac{M\,m}{r^2}$ where $G = 6.664 \times 10^{-8}$; M for Sirius and companion is $3.2 \times 1.983 \times 10^{33}$; m for earth is 5.966×10^{27}; and r is $8.6 \times 9.463 \times 10^{17}$. Rounding off the figures quickly gives 3.8×10^{16} dynes or about 4.3×10^7 tons weight, agreeing well with the author's figures.—ED.

UNDER THE WINTER SKY

(Continued from page 7)

star of the belt, through his head, and as far again, the observer comes to El Nath which marks the left horn of Taurus, the Bull. Continuing this line farther north, one discovers Capella, a brilliant star in the five-sided constellation of Auriga. In middle northern latitudes Capella is very nearly circumpolar. This brilliant star is accompanied by three faint stars of 3rd and 4th magnitude; these fainter stars, which are known as the Kids, serve as a faithful identification mark for Capella itself, whose name means literally the She-Goat. Capella is a glorious yellow or golden star. It is so much larger and intrinsically so much brighter than our sun that whereas Capella shines with an apparent magnitude of —0.3, the sun at the same distance of 42 light-years would appear as a very faint naked-eye star.

One of the more interesting but less familiar groups of stars is the constellation Eridanus, the River. This long celestial stream, which was supposed by some ancient stargazers to be the heavenly counterpart of the River Po, takes its rise near Rigel in the left foot of Orion. Garrett P. Serviss, in his fascinating little book, *Astronomy with an Opera Glass*, describes the course of Eridanus as follows:

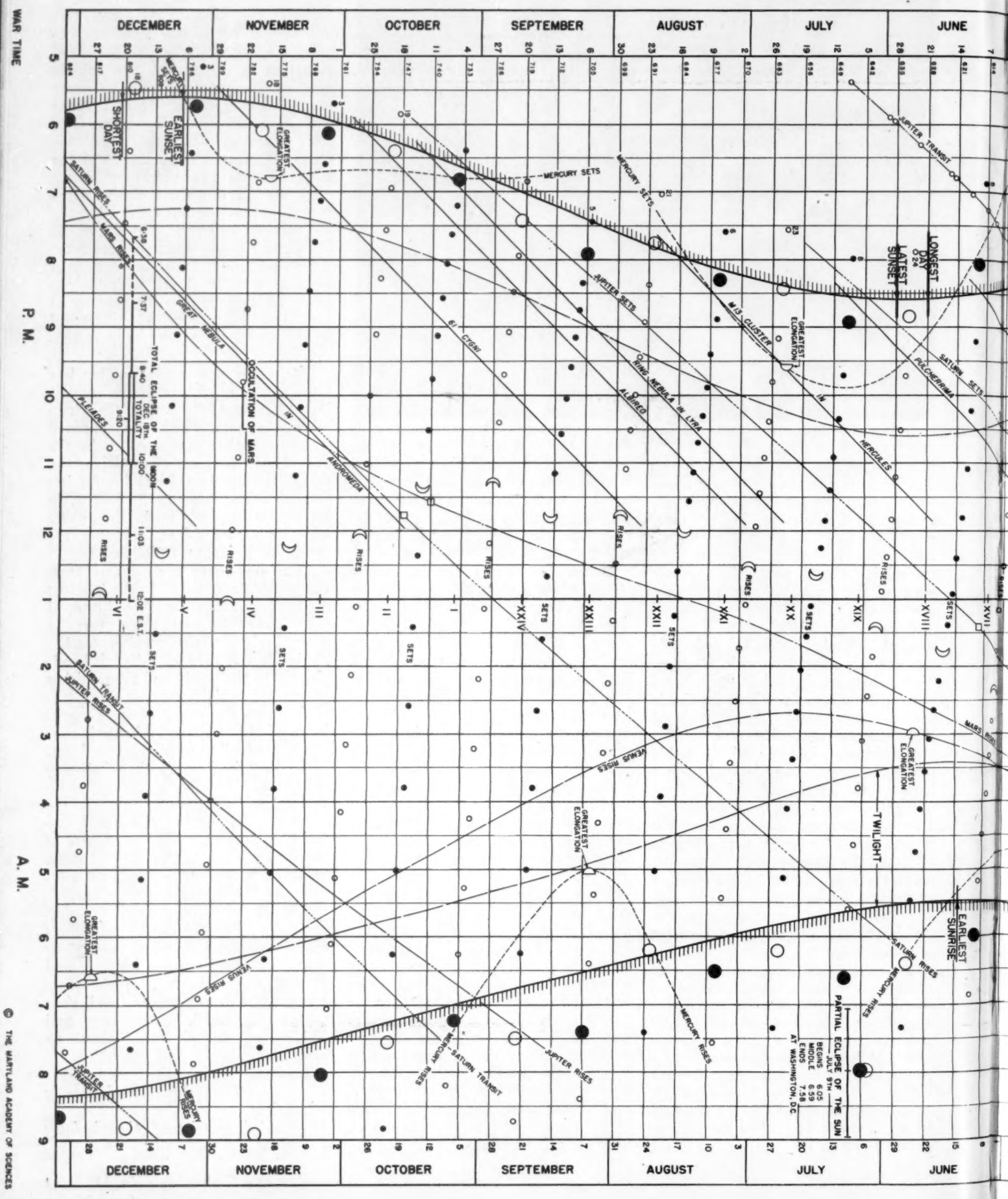
"The imaginary river starts from the brilliant star Rigel, in the left foot of Orion, and flows in a broad upward bend toward the west; then it turns in a southerly direction until it reaches the bright star Gamma, where it bends sharply to the north, and then quickly sweeps off to the west once more, until it meets the group of stars marking the head of Cetus. Thence it runs south, gradually turning eastward, until it flows back more than half-way to Orion. Finally it curves south again and disappears beneath the horizon. Throughout the whole distance of more than 100° the course of the stream is marked by rows of stars, and can be recognized without difficulty by the amateur astronomer."

And so much for some of the winter stars. For the person who finds himself troubled in mind these days —and who does not?—a leisurely and gradual acquaintance with the more conspicuous constellations, and then progressively with fainter stars and harder groups, can bring about an astonishing peace and relaxation.

Look to the sky, where shine the
. . . quenchless stars, so eloquently bright,
Untroubled sentries of the shadowy night.

Graphic Time Table

PREPARED BY THE MARYLA



e of the Heavens - - 1945

RYLAND ACADEMY OF SCIENCES

The Graphic Time Table of the Heavens

while still available may be secured without charge directly from the Maryland Academy of Sciences, Pratt Library Building, 400 Cathedral St., Baltimore 1, Md. Blueprints of the original drawing before reproduction are available at cost—50c each—40 x 27 inches. A special French edition for 47° N. is being prepared.

The Graphic Time Table gives the rising and setting times of the sun, moon, and bright planets; the beginning of morning twilight and the ending of evening twilight; the times when certain stars and other objects of particular interest cross the meridian (that imaginary line which splits the sky into its eastern and western halves); the phases of the moon, and other astronomical information. To illustrate by an example: The events of the night of January 4-5 may be found by following the horizontal line for that date across the page from left to right. The Julian Day number for that evening, of interest to variable star observers, is 2,431,460. The sun sets at 4:48 p.m. standard time (5:48 war time); evening twilight ends at 6:28 p.m. standard time; Venus sets at 8:27 p.m.; the Pleiades cross the meridian at 8:48; the Orion nebula transits at 10:35; Jupiter rises at 10:47; the moon rises at 10:56; Saturn transits at 11:30; Jupiter at 4:53 a.m.; Mercury rises at 5:40; morning twilight begins at 5:43; Mars rises at 6:23; Saturn sets at 6:50; and the sun rises at 7:22 a.m.

The dashes on the sunrise and sunset curves are for interpolation on other days than those indicated. Standard time is shown on the top line, and war time at the bottom; Roman numerals show sidereal time at midnight. The phases of the moon are indicated by the conventional symbols. Small black circles show moonset for the first half of the lunar month, and small open circles show moonrise from full to new moon. The circles on the Jupiter transit curve indicate nights on which occultations or eclipses of Jupiter's bright moons take place between 7:00 p.m. and 10:00 p.m., Eastern standard time. Small squares on planet curves indicate positions at quadrature; opposition is marked by the conventional symbol.

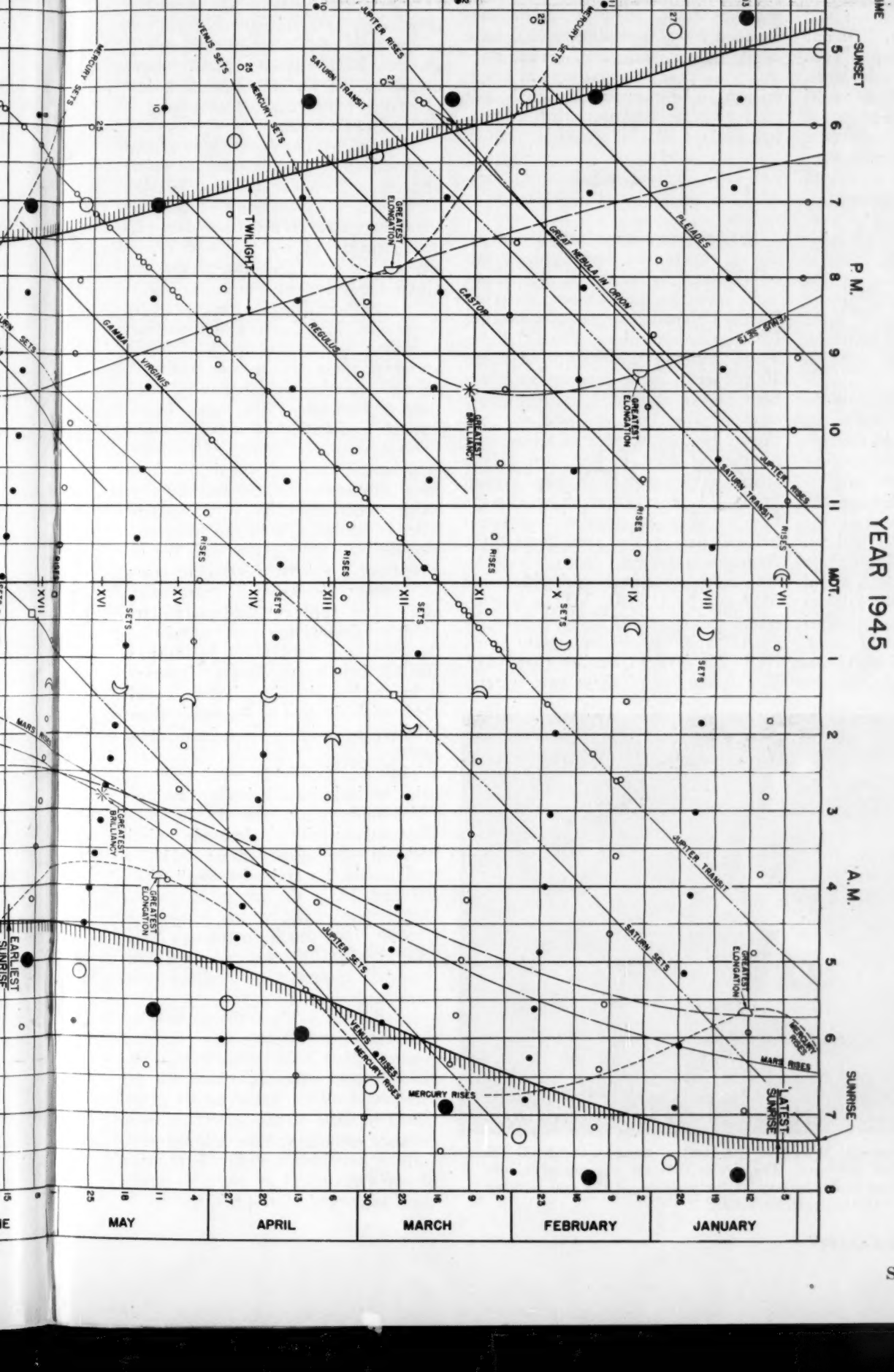
How to Correct for Your Position

As in all almanacs, times of rising and setting of sun, moon, and planets, are absolutely correct for only one point on the earth's surface—for this chart: latitude 40° N. and longitude 90° W. However, the observer may easily correct for his own position. Correction for difference in latitude is comparatively minor—apply the rule that when members of the solar system are north of the equator, they remain visible longer as we go farther north, and for lesser time farther south.

Correction for difference in longitude depends principally on the observer's distance east or west of his standard time meridian, which is always at an even multiple of 15°. Some corrections are tabulated here, in minutes of time:

Atlanta	+38	Denver	0
Baltimore	+ 6	Detroit	+32
Boston	—16	Houston	+22
Chicago	+10	Indianapolis	—16
Cincinnati	+38	Los Angeles	— 7
Cleveland	+27	Minneapolis	+13
New Orleans	0		
New York	— 4		
Pittsburgh	+20		
San Fr'cisco	+10		
St. Louis	+ 1		
Washington	+ 8		

All places with plus correction are west of the standard meridian, and the events will occur later. The usual correction of one hour for each standard time zone must also be made to the Eastern standard times given for lunar eclipses and Jupiter's satellites, and in the Far West slight corrections may be made to times of moonrise and moonset. For times of occultations and solar eclipses, refer to the "American Ephemeris."



BEGINNER'S PAGE

Man and His Expanding Universe — XIII

By Percy W. Witherell

IF a man from a primitive tribe of central Asia were taken in a wooden case on board the *Queen Mary,* and then allowed to look in several directions through holes bored in the sides of the box, he would have a very vague idea of the shape and functions of an ocean liner. To one who had seen large ships, such glimpses would reveal much more, and to a captain of such a vessel many details would be well recognized in spite of the limitations of the view through the holes in the box.

Let us, then, take a look outside of our own galaxy and study the appearance of other systems from which we may get a better idea of the probable structure of our own. Our nearest "sister" among the galaxies is the Great Nebula in Andromeda, Messier 31, which may be seen easily with the naked eye as an elongated patch of light not far from the star Beta in Andromeda.

An amateur's telescope confirms the elongation of this galaxy as we see it, but long-exposure photographs through large instruments are required to show the wealth of detail, and it is only recently that the 100-inch telescope has been used to resolve into stars the very bright nucleus of this galaxy. The Andromeda system is probably a flattened, disk-like spiral, which would appear to us (as many other galaxies do) as a thin wafer were its principal plane directly in our line of sight. That plane is, however, tilted 15 degrees from the line of sight, so the galaxy appears as a rather elongated ellipse. It has a greatest diameter, in ordinary photographs, of about 35,000 light-years, but studies by means of the microdensitometer, an instrument for measuring the intensity of a photographic image, show it to be surrounded by a three-dimensional haze nearly twice this size. The stars which compose this haze are not bright enough to be seen as individuals, but their presence constitutes an interesting analogy to the spherical haze of stars surrounding our own galaxy. In size and general appearance, then, M31 is similar to the Milky Way system.

The Andromeda galaxy is rich in novae, supernovae, and Cepheid variable stars. By means of the periods and apparent magnitudes observed for the Cepheids, the galaxy's distance is estimated at about 750,000 light-years, with an uncertainty of about 10 per cent. The intervening space between us and M31 is reasonably clear of absorbing gas and dust, as shown by the presence of an average number of stars in our own galaxy visible in this part of the sky, as well as by the observation of an average number of much more distant external galaxies in the area around the Andromeda system.

Closely associated with M31 are M32 and NGC 205. M32 is a spheroidal galaxy, 1,800 light-years in diameter and without supergiant stars. NGC 205 is even smaller than M32. The resolution of these two systems and the nucleus of M31 was described in News Notes last month.

M33, a neighbor of M31, situated in the adjoining constellation of Triangulum, is a disk of about 12,500 light-years' diameter, tilted at an angle of some 30 degrees. It has a sphere of faint stars around it and is on the large side, as spiral nebulae go, but it contains only a fraction as many stars as M31. It is a much fainter object as we see it, although a few observers have reported observing it without optical aid.

M31 and M33 have about 50 known Cepheids each, many supergiant stars; and about 25 novae are seen in M31 each year. This is many times more than are visible to us in our own galaxy, because of our point of disadvantage amid the dust and dark clouds along the plane of the Milky Way.

In another direction in space, in Sagittarius, at a distance of about half a million light-years, lies NGC 6822, an irregular patch known as Barnard's galaxy. Another neighbor is IC 1613, located between Pisces and Cetus, but at a distance of about 900,000 light-years.

Recently, two other galaxies have been discovered to be neighbors of ours. One near the south galactic pole, in Sculptor, is in the form of a globular star cluster but with the diameter of a galaxy, 5,500 light-years. It is about 250,000 light-years away, and has no apparent supergiant stars, no open clusters nor gaseous nebulae. Another such system is in Fornax, 500,000 light-years distant; however, it has a few globular clusters associated with it and is several times brighter intrinsically than the Sculptor system.

Thus our family or local group of galaxies includes 11 known systems which we have enumerated: the Milky Way galaxy, the Andromeda spiral, both in the giant class; M33, a medium-sized spiral; the small NGC 205 and M32; the irregular systems of the Large and Small Magellanic Clouds; the small irregulars NGC 6822 and IC 1613; and the small symmetrical systems in Sculptor and Fornax.

In addition to these there are other candidates for admission to the local group: spirals NGC 6946, IC 10, and IC 342, and some six others not yet catalogued. Their status is not determined because of the uncertainties in distance estimates; they all, however, seem to be within a million light-years of our galaxy and so are near neighbors, astronomically speaking.

The triple system in Andromeda: M31, M32 (just left of center), and NGC 205 (below center one inch from bottom). The circles indicate regions with surface brightness equal to that in our galaxy at the position of the sun relative to the galactic center.

Amateur Astronomers

Public Meeting on Detroit Planetarium

THE Detroit Astronomical Society has gained increasing official and public support for its move to procure a planetarium for Detroit. On the evening of October 30th, a joint meeting was sponsored by the society and the Engineering Society of Detroit for the purpose of obtaining information on planetariums and to build up enthusiasm among the people of the city. Over 700 persons gathered at the Rackham Memorial to hear a general lecture on "Stars in the Modern Manner," by Charles A. Federer, Jr., of Harvard Observatory, and another talk on "An American Planetarium in an American Town," by Frank D. Korkosz, designer and builder of the planetarium in the Museum of Natural History in Springfield, Mass.

The all-American instrument's construction furnished the keynote of the evening. During the question-and-answer period following Mr. Korkosz' talk, it was found that this unique projector was built, pre-war, for less than $12,000, but would probably cost nearly three times that much now, still only a fraction of the cost of a Zeiss instrument. It may interest *Sky and Telescope* readers to know that Inventor Korkosz began his career in astronomy as a small boy when his father took him outdoors one night to show him Halley's comet. His early planetarium efforts consisted in entertaining his fellow youths by punching holes in cardboard to represent the stars. In the Springfield Planetarium, to which there is no admission charge, the annual attendance is about 10 per cent of the city's population, comparing favorably with the attendance at any planetarium in the world.

The proposed planetarium has the approval of the Detroit Board of Education and also the City Plan Commission, to the extent, at least, that in tentative plans for a cultural center for the city provisional space for a planetarium building has been allotted.

MARGARET BACK, secretary
Detroit Astronomical Society

INDIANAPOLIS AMATEURS USE R.A.S.C. HANDBOOK

We note in the *Bulletin* of the Indiana Astronomical Society that orders for the *Observer's Handbook* of the Royal Astronomical Society of Canada were taken at the December meeting. The cost to each member was 20 cents if more than 10 were ordered, 25 cents otherwise. Other groups who are not familiar with the very valuable booklet put out by the Canadian society may wish to order it directly from the R.A.S.C., 198 College Street, Toronto, Ontario, Canada.

The *Observer's Handbook* is published annually and contains complete observing data of use to the amateur; tables of Jupiter's satellites, lists of objects for telescopic observing, planet charts, and many other interesting features in addition to the configurations of the planets.

NEW ZEALAND AMATEUR

Murray Geddes, an amateur astronomer whose work and interest carried him so far as to be appointed the first director of the Carter Observatory, Wellington, New Zealand, died in Glasgow on July 23rd, last, his rank in the service of his country being that of lieutenant-commander.

He joined the New Zealand Astronomical Society in 1931, becoming its president in 1940-41, and was vice-president in 1942-43; his loss is therefore keenly felt by members of the society, as well as by astronomers in his own country and elsewhere.

NORTHWEST A. S.

After a lapse of two years, during which time our astronomical society has been almost dormant due to the war activity of its members, we are again reviving on a large scale for the present season.

We have decided to incorporate into our activities lectures by prominent speakers. In addition to our lecture program, Lloyd Sprinkle, president of the society this year and also one of the owners of the Associated Optical Companies of this city, will conduct a course in amateur telescope making. This course is starting sometime in December, to be held once a week during most of the winter. There is no charge for the course and anyone interested is welcome.

Another of our activities is an actual observation program. The undersigned expects to construct an observatory at Union Lake, to be the main observing base for the society until our 20-inch reflector, which is now well under way, is completed.

E. P. HOLLERAN
Northwest Astronomical Society
12305 Turner Avenue
Detroit 4, Mich.

THIS MONTH'S LECTURES

Cincinnati: At the meeting of the Cincinnati Astronomical Association on Friday evening, January 12th, "Professional Optical Methods" will be discussed by Nicholas P. Miceli, Panocular Company, Cincinnati, and "Amateur Optical Methods" is the title of a talk by George W. Gasper, who is instructor in telescope making for the society.

Cleveland: "Stellar Systems" will be the subject of the lecture by Dr. G. Van Biesbroeck, of Yerkes Observatory, to the Cleveland Astronomical Society, January 5th at 8 o'clock in the Warner and Swasey Observatory.

Detroit: On Sunday, January 14th, at 3 p.m. at Wayne University, Prof. Buford L. Pickens, of Wayne University, will talk to members of the Detroit Astronomical Society on the proposed Cultural Center project, whose plans include space allotted for a planetarium. The annual business meeting and election of officers will follow.

Madison: Dr. Joel Stebbins, of Washburn Observatory, will address the Madison Astronomical Society on "The Andromeda Nebula," on January 10th at the observatory.

New Haven: At the anniversary meeting dinner on January 20th, for members of the New Haven Amateur Astronomical Society, Dr. Dirk Brouwer, of Yale Observatory, will be principal speaker.

New York: "Forecasting Astronomical Events" will be discussed by Jesse A. Fitzpatrick at the January meeting of the Amateur Astronomers Association. The meeting is at 8:00 p.m. on January 3rd at the Roosevelt Memorial building of the American Museum of Natural History. Guest tickets may be had by calling the society headquarters in the Museum, ENdicott 2-8500.

Philadelphia: The retiring president of the Rittenhouse A. S., Dr. Peter van de Kamp, will speak on "Stars, Atoms and Man," at 8:00 p.m., January 12th.

CLEVELAND PUBLIC NIGHTS

The Warner and Swasey Observatory has scheduled public nights for the 25th and 26th of January. Following a lecture on "The Sun, Our Nearest Star," at 8 o'clock, there will be observation through the telescope. For reservations, call the Case School of Applied Science, GArfield 6680.

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BOOKS AND THE SKY

MEN OF SCIENCE IN AMERICA

The Role of Science in the Growth of Our Country

Bernard Jaffe. Simon and Schuster, New York, 1944. 600 pages. $3.75.

THE two parts of the title of this highly interesting book might have been reversed; likewise, the 20 chapters, each headed by the name of a leader of science, have below each name a subtitle that shows the real field of the chapter, although sometimes more to catch the reader than to show the exact field. The Hubble chapter, as an example, goes back to Rittenhouse and even four centuries farther to Copernicus—it might well have been entitled, "The story of the enlargement of man's knowledge of the universe by telescope and camera and spectroscope." Similarly, Chapter 7 might have been entitled, "The story of the evolution of anesthetics and abdominal operations."

As George Sarton, who has been the backbone of the History of Science Society, remarks in his foreword, "science is international." This is shown by the birthplaces and ancestors of the scientists selected to head the chapters. Naturally, most of the earlier men were born in Europe, but among the more recent men also born abroad were Agassiz and Michelson. Moreover, the scientific work of a number was mainly recognized in Europe. The relative youth of American science is such that only the first six of the 20 chapter heads refer to men not living since I was born; my personal recollection begins halfway through with Agassiz (Chapter 10) and Dana (Chapter 11).

Discovery and travel played a large part in the life and work of the earlier men. Dana started early on a voyage of discovery in which he anticipated Darwin's theory of coral islands. From J. Walcott Gibbs to the present, however, mathematics and laboratory work and calculation played a greater part. To the astronomer the two chapters bearing the names of Hubble and Lawrence are of especial interest; here are found names of investigators familiar to readers of **Sky and Telescope:** Alvan Clark, Henrietta Leavitt, Henry Norris Russell, Harlow Shapley. The Lawrence chapter recounts the growth of the cyclotron and the study of the very small.

It is noticed that the men selected by the author were not in general narrow specialists. J. Henry occupied at Princeton not a chair but a settee: architecture, astronomy, chemistry, and mathematics; he did experimental investigation in several lines of physics. Even more recently we find J. Loeb advising H. M. Evans, "Don't be a classified scientist. Step out with the new fields and don't be afraid of impinging on other fields."

The author does not seem to have been influenced by unconscious bias as to the social position and schooling of the men selected. Personal matter in each chapter shows how the scientist fitted into the social, political, and religious structure of the times. Hubble's career is not conventional. Amateur prize fighter (invited to be professional), Rhodes scholar, lawyer, major in the first war, he picked up astronomy again and built on a foundation laid here in Cambridge to study the expanding universe — not expanding fast enough to keep up with man's expanding curiosity.

Since Jaffe seems to be much more objective in that respect than many writers, it is interesting to inquire if there is any correlation (such as Leuba suggested) between distinction in science and leaning to the right or left wing in politics, or religion. Certainly there is no high correlation. On the right we have Benjamin Thompson, Count Rumford, of Tory affiliations, and Maury, Confederate naval officer. On the other hand, Cooper and Say, in their early surroundings, certainly belonged with the left.

The religious lines are not exactly accordant with the social or political. If one may adopt Leuba's triple classification into theists, deists, and atheists or agnostics, perhaps most of these scientists would be in the middle group headed by Benjamin Franklin and coming down through Agassiz. Yet some, such as Dana and Maury, were deeply religious; perhaps none was rampantly atheistic.

Here is a book in which one may also find impartially developed the sins of scientists. They are what might be expected from science's driving force, which is curiosity. This impels the explorers, was aroused in Henry (page 186) by a book on experiments full of "why." Another motive not confined to scientists but responsible for many of our sins is the desire to be first, first to explore new lands, or reach the poles, or name a new form, which became a regular craze with Rafinesque (page 116), or first to propose a new theory, or to make a new invention. Disagreements in science often occur and help progress; thanks to the moral quality of the men, the discussion of evolution in this country in early days between Asa Gray and his colleague, Agassiz, and the attitude of Agassiz' students, never had the bitterness which cropped out occasionally even in Darwin when he referred to "sugar of lead." Leaders like Lyman Abbott, Henry Drummond, John Fiske, and Dana, smooth things over.

It may be noted that the chapters on

NEW BOOKS RECEIVED

AMERIGO VESPUCCI, Pilot Major, *Frederick J. Pohl*, 1944. *Columbia University Press.* 249 pages. $3.00.

The story of the authenticated achievements of the man after whom two continents are named, based on an acceptance of only the two voyages which are described in his genuine letters.

Gibbs (13), Michelson (15), Hubble (18), and Lawrence (19), give the story of modern physical chemistry, while chapters on Agassiz (10), Dana (11), Marsh (12), Morgan (16), and Evans (17), are more concerned with progress in the study of life—biology.

The concluding chapter of the book is prophetic, and it may be taken in connection with the earlier chapters, 8, 9, and 11, in studying the past and future relative importance of state-supported, corporate endowed, and individual science. Here the author recognizes the value of the various forms of support, and his obviously keen interest in the place of the scientist in society (page 552) leads him to look forward to an even larger place, and to end with an apt quotation from Wendell Willkie's **One World.**

There is a good index, important in a book of this type; a full table of contents and lists of illustrations and plates. The reference on page 191 should be to the plate on page 217.

ALFRED C. LANE
Professor emeritus, Tufts College

LETTER TO THE EDITOR

(Continued from page 2)

day to local sheets of water. Between the first and last contacts no food or water may be partaken of, even food cooked in pots being thrown away together with the utensils, and people are requested to recite mantras or prayers and call upon the gods. During the month of the eclipse no marriages take place and at least a week must elapse before long journeys are undertaken. To disperse the evil influences that overcast the earth at eclipse seasons charitable acts are encouraged.

A. T. G. BRITO
Colombo, Ceylon

July 31, 1944.

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THE BOOK CORNER

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NEWS NOTES

(Continued from page 9)

100 million times brighter than the sun and several thousand million times more massive. These figures would indicate values for the radius corresponding to the 2,400 megaparsecs already mentioned as the upper limit derived from the observed expansion. Eddington, however, feels that astronomers are tending to increase their estimates of the masses of galaxies, and of the matter in the space between them, so he chooses a most probable value for the present radius of the expanding universe of about 1,500 million parsecs, or about 5,000 million light-years. The total number of galaxies in this space is probably about 3×10^{11}.

Once the present size is established, it is possible to compute just how long ago the universe had a certain radius. On the assumption, formerly thought probable, that the universe started expanding from a *geometrically* uniform equilibrium state, Eddington finds that the time taken to arrive at its present state would have been logarithmically infinite. If, however, the more useful assumption is made that it started from a *statistically* uniform (by and large, uniform, but with local irregularities) equilibrium state, the time required to reach the present state is about 90,000 million years. On a date only 8,000 million years ago "it ceased to be possible for light to travel right around the universe." And about half way between then and now, "the universe burst. Previously, it was ideally possible for a ruler, issuing orders by radio, to influence future events in *every* part of the universe." Travelling at the speed of light, orders issued since that time cannot reach a galaxy on the opposite side of the universe for any time less than infinite; also, parts of the universe are entirely beyond the spheres of causative influence of other parts.

Eddington considers the extreme limit of 90,000 million years the result of "a fantastic extrapolation," and prefers to say that "the system can be traced back for, say, 30,000 million years without straining credulity." But neither of these values allows time for the formation of condensations in a uniform primordial distribution of matter from which galaxies were to develop; nor does the problem of the origin of the rapid rotation of the observed galaxies receive consideration in this discussion. Therefore, he expects modification of the theory presented in the paper as well as of these time estimates.

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Fine Grinding. About eight to 12 charges of each fine grade are ground down, according to the pressure used. The purpose of each successively finer grade is to remove the pits left by the preceding grade. A smaller quantity of the fine abrasives will suffice for a charge, and they can be ground for a longer period. In using #400 and finer, deposit it at the center of the tool, add water, puddle and spread it with the finger. And beware of the disks sticking together. As the fine grades break down, evaporation may cause them to stick, so add water frequently. Or the suction caused by imperfect contact may cause it. If they do stick, use a carpenter's wooden clamps to separate them, or wedge the tool on a bench, hold a block of wood against the side of the mirror, and free it with a blow of a hammer.

We might go through fine grinding keeping the mirror on top, in which case strokes of ½" length should be used. But even these very short strokes will reduce the radius, by perhaps two or three inches, and some allowance for this deepening of the curve would have to be made in the rough grinding. The experienced mirror maker can estimate this allowance nicely, but it is rather indeterminate for the tyro.

So for the last three or four charges of each of the fine grades, we will invert the disks, and grind with the tool on top. One-third strokes should be used throughout. In this way we have a control on our focal length. This method also has the advantage of giving an equal amount of abrasion at the edge, where the least action takes place in the usual mirror-on-top grinding, and we are less apt to have pits in that area. Either method of grinding will bring us through with a spherical figure. We should aim at emerging from the fine grinding with a focal length of 48½". Polishing usually shortens this by ½".

Before leaving #120, work the last charge down well, then follow with a charge of #400 (worked with the mirror on top), and again test for focal length. This time we have a surface which, when wet, will be capable of producing a fairly sharp image of the window of the Foucault lamp. Use a piece of ground glass to pick up the reflection from the mirror, and adjust the lamp until it and the sharply focused image of the window are equally distant from the mirror. Half this distance is the exact focal length, which should not be more than 49" at this stage. If it is found that a slight correction must be made, of an inch or two, it should be done on this grade. Any greater correction should be made with #80.

Examining for Pits. Hold the clean, dry mirror before a light, and with the magnifier examine the texture of the surface at the center. The pitted surface should appear uniform, with no intermingling of large pits. Compare it with an area out near the edge. There should be the same uniformity of surface, indicating that grinding is going on evenly. It may be helpful to cut up four small squares of plate glass and grind them together in this fashion: 1 and 2 with #400, 2 and 3 with #220, 3 and 4 with #120, thus providing ourselves with comparison surfaces of those grades.

Not less than 40 minutes should be spent on each grade. Do not attempt to shorten this time by using a rapid stroke, as this may result in a flattened edge.

Clean up thoroughly before passing from one grade to another. Do not try to clean every last Carbo grain out of the pail each time. Well-behaved grains will remain at the bottom. Wash the handle and rim, and keep clean water in the pail. Keep the edges of the mirror and tool beveled.

It is impossible to bring the surfaces into absolute contact with #80 because of the presence of the abrasive. But this improves as finer grades are used. It can be materially helped by frequently separating the disks and re-distributing the abrasive. With the last two grades, the tiny bubbles which have always been present in the mixture should be eliminated before going ahead with grinding. Do this by slowly moving the mirror out over the tool, rotating it the while, and the bubbles will be found to disappear over the edge, leaving nothing but a thin film of water and abrasive between the disks.

The final charge of #304 emery should be worked with the mirror on top, using very short strokes, about ½" long, for about 20 minutes, adding water when necessary. If the tool is of the recommended thickness, pressure can be advantageously maintained throughout fine grinding.

Through a properly fine-ground mirror that is ready for polishing, it should be possible to read 14-point type held at a distance of several inches.

IV — THE PITCH LAP

Making the Lap. We are now ready for the pitch lap. First, make a waxed paper collar which is to be wrapped around the tool to retain the hot pitch. Cut a strip of newspaper at least 20" long, and ¼" wider than the thickness of the tool; run it through some melted paraffin and set it aside. Melt the pitch slowly on the stove, in a pot or can. It

is inflammable, so keep the flame low, and have on hand a wide board or other cover which can be immediately placed over the pot to smother any flames. Use a wide, thin stick for stirring. If a can is being used, it may be gripped with a pair of pliers while pouring. When the pitch is fully melted, pour a large drop onto a piece of scrap glass and let it cool. Try denting it with your thumbnail. If after about 15 seconds of pressure, there is hardly any indentation, the pitch is too hard; too soft if it has yielded easily. Some mirror makers use the bite test, although this is even less determinate than the thumbnail test. Chip the cold drop of pitch off the glass and place it between the teeth. If it immediately shatters into fragments under a bite, it is too hard. There should be just the slightest yielding before breaking.

To soften pitch, add a few drops of turpentine. **Do not do this over the stove.** Stir thoroughly and try the temper. It takes very little turpentine for this, so use it cautiously. To harden pitch, cook it for a long period. Adding a quantity of rosin will harden it. No two pitches are alike, so exact proportions cannot be given, but the amount of rosin added ought not to exceed the volume of the pitch. Some laps are made entirely of rosin, tempered with turpentine. These are suitable for hot climates.

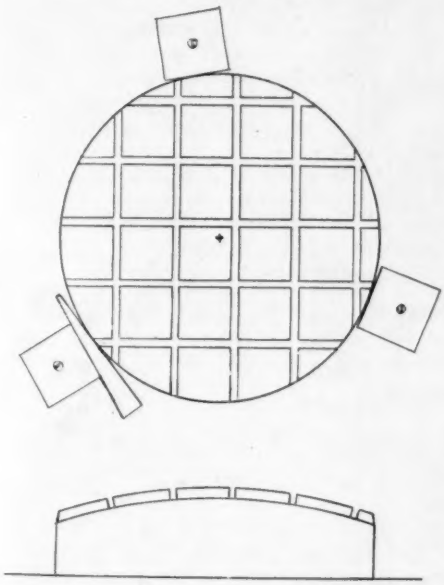

Fig. 13. The channeled lap.

While the pitch has been melting, partially fill the pail (which has been thoroughly cleaned out) with water as hot as the hands can tolerate, and completely immerse mirror and tool, standing them on their edges and resting them against the sides of the pail, so that you can reach them quickly when you want them. Have a piece of soap on hand in a clean dish. The tool and mirror should be allowed to heat through before pouring the lap. After the pitch has been fully melted and tempered, remove it from the stove and allow it to cool slightly, as it is best not to pour boiling hot pitch onto the tool. Now remove the tool from the hot water, dry it, and wrap the paraffined paper collar around it. There is enough heat in the glass tool to cause the overlapping ends of the collar to adhere. Give the pitch a final thorough stirring and pour it onto the tool up to the level of the collar. When it has thickened enough to retain its shape, remove the collar.

Soap the channeling tool and press the channels into the warm pitch right down to the glass, as in Fig. 13. Start at the center, and locate them so that the center of the tool will lie just inside a corner of one square. A uniform distribution of the squares often results in a series of raised rings on the mirrir, visible under the Foucault test. Press the channels in one direction first, then press the other set at right angles. Take the mirror from the hot water, quickly soap its surface, and slide it about on the lap, gradually increasing the pressure. The channels will be closing in now, so replace the mirror in the hot water, and go over the channels again. Follow with the soaped mirror. These steps may have to be repeated three or four times before the lap has sufficiently hardened to retain its shape. By proper manipulation, any tendency for concavities to develop in the squares can be ironed out. By the time the pitch has hardened, the lap should exactly conform with the curve of the mirror. Remove the mirror and wash it off in clear water.

Using a sharp knife, with a firm shearing stroke cut away the pitch overhanging the edge of the tool. Incline the knife so as to give a slight bevel to the lap. The knife or a razor blade may be used to widen any channels that have closed in. Do this cautiously or large chunks of pitch may break out. One eighth of an inch is a good width for the channels. Flush the lap under a cold-water tap to clean off the soap and any pitch fragments, and dry it. Melt down some beeswax in a can. Prepare a brush for the wax: a thin stick of wood, 1" wide, chisel-shaped, with three or four thicknesses of 1" gauze bandage wrapped over the edge and tied with thin string. Soak this in the melted beeswax (which should be smoking hot) and draw it across the lap, covering each square with a single stroke of the brush. Two or three squares can be done on a single dipping. While we might polish directly on the pitch or rosin lap, the beeswax coating gives a faster, sleek-free polish, and results in a better edge. Sleeks, or micro-scratches, barely visible on a polished surface, may result from coarse rouge particles and a hard lap.

Making Contact. Obtain clean, hot water in the pail and place the lap in it. The purpose here is to soften it slightly so that it can be pressed into perfect contact with the mirror. Making contact in this way should precede each daily polishing period. The barrel top has now been fitted with three wooden cleats (Fig. 13), and clean paper, cut out to fit over the cleats, is placed on top. Put a spoonful or two of rouge in a clean jar, add water and stir. Use a small paint brush to apply the rouge mixture to the mirror. About three minutes in the hot water will suffice for the lap. Place it on the barrel top, wedged firmly between the cleats. Immediately place the rouged mirror on top and work back and forth vigorously and with pressure for about 15 seconds in order to embed the rouge in the wax coating of the lap. Then, with the mirror centered on the lap, place a 10- to 15-pound weight on it, and leave it for about 15 minutes, until all of the heat has gone out of the tool. A wide board placed under the weight will distribute the load evenly.

A Better Lap. The channeled pitch lap just described is the conventional one used by both amateur and professional mirror makers. A better lap, developed by Dr. Henry L. Yeagley, of Penn State College, is fully described in The SKY, March, 1938, and **Sky and Telescope**, July, 1944.

(To be continued. Next month polishing and testing will be described.)

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36 mm.	182 mm. Focal Length	$2.00
18 mm.	95 mm. " "	$2.00
30 mm.	50 mm. Plano-Convex	$1.00
2"x2" Pyrex Optical Flat, ½-wave		$5.00
Front-surface Mirrors 1⅜"x2 5/16"		$2.00

Send for Free List

MAYFLOR PRODUCTS CORP.
Katonah, N. Y.

SKY-GAZERS EXCHANGE

Classified advertisements are accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge 38, Mass.

Because of the death of Theodore E. Jaslerski the following items are for sale: patterns, drawings, grinding and polishing machine, all specially made tools, glass blanks, castings and so forth. Phone evenings or write E. Jaslerski, 3222 N. Hamlin Ave., Chicago 18, Ill. Keystone 5589.

FOR SALE: 10" aluminized mirror; focus about 90"; good condition, $60. Write James Bray, 860 Walnut Avenue, Burlingame, Calif.

FOR SALE: 4" Mogey refractor; focal length 54"; achromatic; excellent definition; altazimuth mounting; oak tripod; finish white. Oculars 56, 75, 165, 280 power; 42 power terrestrial; Barlow lens, doubling power eyepieces; prism diagonal; sun glass; brass dew, dust caps; wood case. Make offer. N. W. Vancil, 42 Wildwood Road, Scarsdale, N. Y.

WANTED: 11" disk of glass, 1½" or more thick. Will buy or exchange eyepiece or eyepieces for it. Must be suitable for use for speculum. Louis E. Silverthorn, 1814 Flint Ave., East Akron, Ohio.

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

TRANSITS OF JOVIAN SATELLITES—A CORRECTION

READERS of this page in the issue of last May, 1944, may recall my enthusiasm for what I predicted would be a spectacular emergence from transit of Jupiter's satellites I and II, Io and Europa, during the evening of May 4th. My description of this event was partially based on the assumption that the planes of the orbits of Jupiter's bright satellites coincided with that of the equator of the planet. This assumption agrees with that used in constructing the diagrams of the configurations of Jupiter's satellites given monthly in the **American Ephemeris** (see 1945 **Ephemeris**, page 424).

However, since the event of May 4th, an interesting correspondence has been carried on with Walter H. Haas, of Upper Darby, Pa., who made his observations of the simultaneous emergence of I and II with the 18-inch refractor of Flower Observatory of the University of Pennsylvania. On the 6th of May, Mr. Haas wrote, in part:

"The occultation of Jupiter I by Jupiter II on May 4-5 was observed with 400x in poor seeing and a slightly hazy sky. The two satellites were in transit until about 10:56 E.W.T., and they blended so well with the disk of Jupiter near the limb that the beginning stages of the occultation could not be observed. At 10:55 an apparently single moon, necessarily mostly II, was seen. This object remained single until 11:02; the occultation was apparently sensibly annular, since I is the larger moon. I noted an elongation **east-west** of the object at 11:03.1, an effect of the inner satellite emerging from occultation. Last contact was timed at 11:13.2, estimated maximum error 0.3 minutes. The positions of the objects about 11:18 showed that the passage of I behind II must have been practically central.

"It is certain that the apparent distance between the centers of the two moons was much less than 1/3 the diameter of either, and not as predicted by Mr. Fitzpatrick in his article in the May issue. I could discern no north-south elongation of the combined image between 10:55 and 11:02."

Simultaneously, I had written the editor of this magazine concerning my own observations from my apartment-house roof in New Rochelle, N. Y. I mentioned that haze held us down to 100x with my 4½-inch refractor; we tried 150x but it was of no use. At 11:02 we could see the "satellites" in the clear, and the elongation seemed quite apparent, its major axis paralleling Jupiter's for about 10 minutes. At 11:20 I could see a separation, but others observing with me could not detect it until 11:30, when it was very noticeable.

At that time I also mentioned that these observations seemed to confirm my assumption of the coincidence of the orbits with the planet's equator, but in our subsequent correspondence Mr. Haas enclosed a copy of a letter, dated February 27, 1942, addressed to planetary observer Hugh M. Johnson, of Rochester, by Dr. W. J. Eckert, director of the U. S. Nautical Almanac, as follows:

"The nodes and inclinations of the satellites [of Jupiter] are referred to the planes upon which their respective nodes regress. These planes lie very nearly in the plane of Jupiter's equator and pass through the intersection of the planes of the equator and orbit. The inclinations of the satellite orbits to these planes are:

I	0°.0272 = 1'.6	3°.112
II	0°.4683 = 28'.1	3°.097
III	0°.1839 = 11'.0	3°.038
IV	0°.2536 = 15'.2	2°.712

"Jupiter's equator is inclined 3°.115 to its orbit. The inclination of the reference planes of the satellites to the orbit are [given in the righthand column above]."

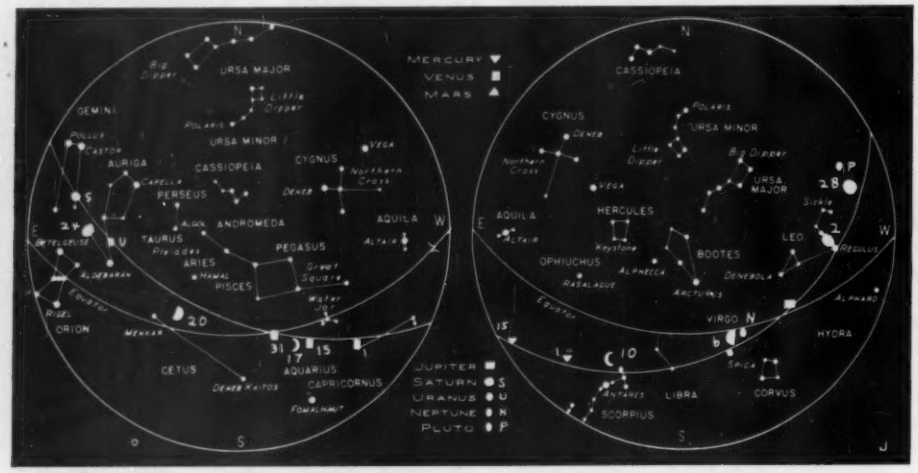
Mr. Haas further points out:

"You will see that the tilt of the orbit of II to the plane of the equator of Jupiter is far from negligible in our problem and that a mathematical procedure much more involved than the one our colleague used is demanded. On page 3 of the 1943 **Handbook** of the British Astronomical Association one reads: 'The plane of the orbits of Jupiter's satellites is turned toward the earth at the end of the year, and a new series of mutual eclipses and occultations is to be expected. Unfortunately, it was found to be impossible, under present conditions, to obtain the necessary data for the prediction of these phenomena.' I think that the missing data were formerly supplied by **Connaissance des Temps.** There is a statement similar to the one quoted above on page 18 of the 1944 **Handbook,** indicating the intricacy of the problem of making these predictions.

"There still remains the problem of why Mr. Fitzpatrick and his guests saw the phenomenon to be different than I

BY JESSE A. FITZPATRICK

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 8:30 a.m. on the 7th of the month, and at 7:30 a.m. on the 23rd. At the left is the sky for 6:30 p.m. on the 7th and for 5:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury, in Sagittarius, will be at greatest elongation west at 11:00 p.m., January 12th. This is a fairly favorable elongation.

Venus is very conspicuous throughout the month, reaching magnitude —4.0 by the 31st; it can easily be observed before sunset if its position on previous evenings has been determined with reference to terrestrial objects.

Earth will reach perihelion, the point in its orbit nearest the sun, on the 1st of January at 7:00 p.m.; the sun's distance will then be 91,443,000 miles.

Mars is too close to the sun to be of interest.

Jupiter is becoming more favorably situated, beginning its retrograde motion in Virgo on January 12th.

Saturn, conspicuous in the eastern evening sky, continues to retrograde in Gemini.

Uranus. On January 4th, this planet will be 5°.5 north of Aldebaran. See accompanying diagram.

Neptune is in Virgo, starting its retrograde motion on the 8th of the month. See accompanying diagram.

recorded it. I feel that the many-times-larger 18-inch refractor must have supplied a better view of a phenomenon which takes place on an extremely small scale. A possibility is that markings on the satellites gave rise to incorrect impressions of position in a small telescope; for example, if the south half of II were darker than the north half, then I might well **seem** shifted southward with respect to II. Furthermore, irradiation and other effects can be very deceptive.

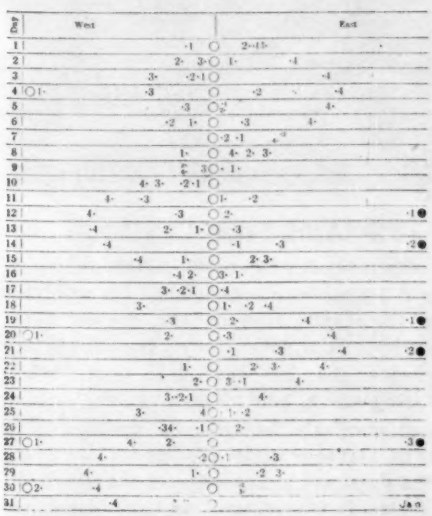
"In my own case, my observational errors in the past have been too numerous, but I have become an Antoniadian in recent years to the extent that I am convinced of the superiority of large telescopes for most visual lunar and planetary studies. This superiority is especially notable for such small bodies as the Jovian satellites. In the case of the 18-inch, this instrument has recently revealed Jupiter II in transit when the satellite was near the central meridian of the planet. Mr. Johnson writes that he can find no comparable observations in all the **Jupiter Memoirs** of the B.A.A., though there are some records of the invisibility of II in the position in question."

Space does not permit inclusion of further examples Mr. Haas gives of the performance of the 18-inch refractor, but in the near future we shall publish a detailed report by him on his observations of Saturn. Meanwhile, we are grateful for his interest and the information, of value to all observers, which he has provided during this discussion.

JUPITER'S SATELLITES

On January 7th, after 3:47 a.m., the four bright moons will be east of the primary. On the 10th, in the early morning, and on the 30th, late at night and on the following morning, these satellites will be west of the planet.

Jupiter's four bright moons have the positions shown below at 5:00 a.m., E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris and Nautical Almanac.**



OCCULTATIONS—JANUARY, 1945

Local station, lat. 40° 48'.6 north, long. 4h 55m.8 west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Jan. 17	7.5	BD —10° 6098	6:56.2 p.m.	107°		
20	6.9	BD +6° 324	9:00.4 p.m.	33°		
23	6.1	302 B Tauri	6:02.7 p.m.	53°	7:11.8 p.m.	266°
23	6.8	BD +18° 734	7:19.1 p.m.	102°		
23	5.1	i Tauri	9:09.6 p.m.	130°	9:51.7 p.m.	195°
23	6.2	312 B Tauri	11:34.7 p.m.	27°	0:27.5 a.m. (24)	313°
24	5.9	BD +20° 1105	8:59.4 p.m.	135°	9:42.8 p.m.	201°
26	5.2	d Geminorum	0:27.2 a.m.	129°	1:34.1 a.m.	238°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

OCCULTATIONS FOR TEXAS

Several observers are now making occultation observations in the region around the station 93° 0'.0 W., and 30° 0'.0 N., for which occultation predictions have been provided by the U. S. Naval Observatory staff and published here during 1944.

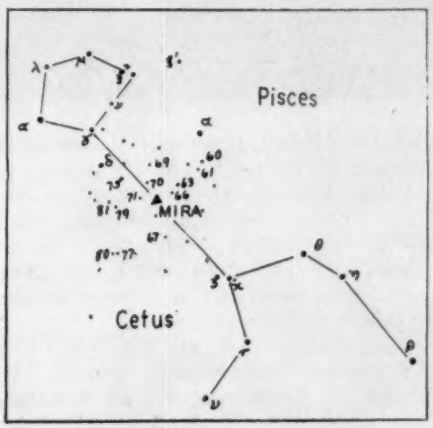
Inasmuch as these predictions for 1945 will appear in **Popular Astronomy** and the **Texas Observers' Bulletin**, we shall discontinue their publication, and suggest that prospective regular observers either refer to one of these publications or communicate directly with the U. S. Naval Observatory, Washington 25, D. C.

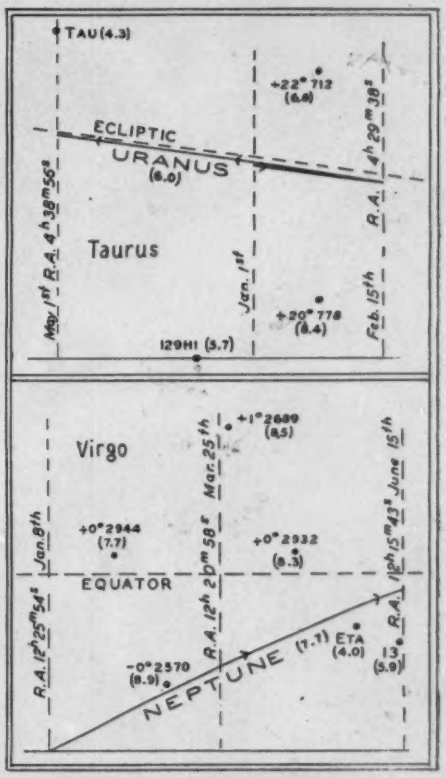
MIRA'S MAXIMUM

The famous long-period variable star, Omicron Ceti, usually known as Mira, will attain its maximum brightness about the end of the month, when it will probably reach magnitude 3 or 4, with the possibility of its becoming the 2nd magnitude or brighter.

The chart below will help the observer to distinguish Mira from its neighbors. It is a red star, so care should be taken in comparing its brightness with the bluer stars around it. The following are magnitudes and spectral classes:

Mira, var., M7; Beta Ceti, 2.3, KO; Alpha Ceti, 2.8, Ma; Eta, 3.6, KO; Tau, 3.7, KO; Gamma, 3.7, A2; Theta, 3.8, KO; Zeta, 3.9, KO; Delta, 4.1, B2; Upsilon, 4.2, Ma; Psi², 4.4, G5; Mu, 4.4, FO; Psi¹, 4.5, G5; Lambda, 4.8, B5; Xi, 4.8, FO; Nu, 5.1, G5; Alpha Piscium, 3.8, A2.





THE PATHS OF URANUS AND NEPTUNE

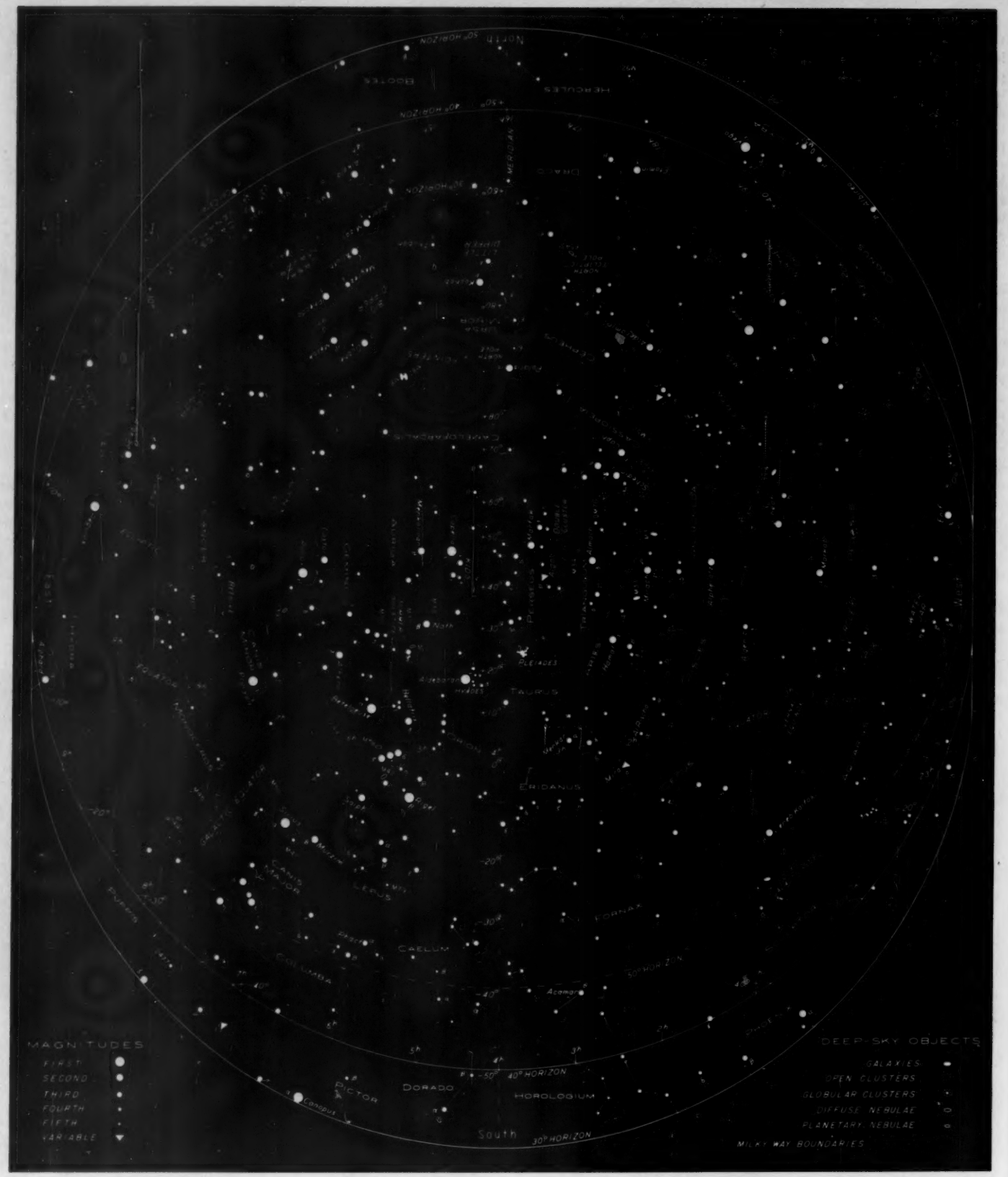
The accompanying diagrams show the paths of Uranus in Taurus and Neptune in Virgo from January 1st to May 1st and from January 8th to June 15th, respectively. On January 3rd, Uranus will be three degrees south of the ecliptic; this celestial latitude will change to —1° on May 1st, when the planet will be 44′ south of Tau Tauri. Neptune will be in opposition to the sun on March 25th, the midpoint of its retrograde motion. On March 10th, the planet will be 3′ south of BD —0° 2570; and 7′ north of Eta Virginis on May 7th.

PHASES OF THE MOON

Last quarter ....January 6, 8:47 a.m.
New moon .....January 14, 1:06 a.m.
First quarter ....January 20, 7:48 p.m.
Full moon .....January 28, 2:41 a.m.

MINIMA OF ALGOL

Jan. 1, 5:00 a.m.; 4, 1:50 a.m.; 6, 10:39 p.m.; 9, 7:28 p.m.; 21, 6:45 a.m.; 24, 3:34 a.m.; 27, 0:24 a.m.; 29, 9:13 p.m.



DEEP-SKY WONDERS

AMONG marvels for observation in the January skies are the objects listed here. The informal descriptions give appearance in common telescopes. Norton designations are in parentheses.

Perseus. Double Cluster, h-x, $2^h\ 12^m$, +56° 41′. Handsome opera-glass object; can be seen with the unaided eye; in line with Gamma and Delta Cass.

Lepus. M79, $5^h\ 21^m.9$, —24° 34′; globular. Small, round, dim in amateur telescopes; near a bright star.

Canis Major. M41, $6^h\ 42^m.7$, —20° 38′; a cluster of 50 stars; bright, overflowing the field.

Puppis. NGC 2440 (64^4), $7^h\ 40^m$, —18° 04′; planetary; it is wee, bright in common telescopes.

Ursa Major. M97, $11^h\ 12^m$, +55° 19′; the famous Owl nebula; among the largest of planetaries, 3′.3 in diameter.

L. S. COPELAND

STARS FOR JANUARY

from latitudes 30° to 50° north, at 10 p.m. and 9 p.m., war time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for transplanted amateurs who may wish to visit other groups. The asterisks denote societies whose members receive *Sky and Telescope* as a privilege of membership.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	*Bond Ast. Club	1st Thu.	8:15	Oct.-June	Harvard Obs.	Miriam Bond, Harvard Observatory
"	A.T.M.s of Boston	2nd Thu.	8:15	Sept.-June	Harvard Obs.	F. A. Pflug, 685 Centre St., Jamaica Plain
BROOKLYN, N. Y.	Astr. Dept., B'klyn Inst.	Rd. Table 3rd Thu.	8:15	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.s & Observers	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	Barnard A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 326 James Bldg., *CHat.* 7-1936
CHICAGO	*Burnham A. S.	2nd, 4th Tue.	8:00	Sept.-June	La Salle Hotel	Miss W. Sawtell, 928 N. Harvey Ave.
CINCINNATI	*Cin. A.A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
CLEVELAND	Cleveland A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH	D. B. Stargazers	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	Detroit A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	Northwest A. S.	3rd Tue.	8:00	Sept.-June	Redford High Sch.	E. P. Holleran, 12305 Turner Ave.
DULUTH, MINN.	Duluth Ast. Club	Meetings suspended				Ray S. Huey, 1822 E. 3rd St.
FT. WORTH	Tex. Observers	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	Ala. A.A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	Indiana A.A.	1st Sun.	2:15	All year	Odeon Hall	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	Joliet A.S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Mrs. Robert L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	———	2606 W. 8th St.	A. M. Newton, 2606 W. 8th St.
LOUISVILLE, KY.	L'ville A.S.	3rd Tue.	8:00	Sept.-May†	University Center. Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct. *Taylor* 4157
MADISON, WIS.	Madison A.S.	2nd Wed.	8:00	All year	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
MEMPHIS	A.T.M.s of Mem.	Alt. Tue.	7:30	All year	Private houses	James Woody, 1056 Linden Ave.
MIAMI, FLA.	Southern Cross A.S.	Every Fri.	7:30	All year	M. B. Lib. Grounds	A. P. Smith, Jr., 426 S.W. 26th Road
MILWAUKEE	Milw. A.S.	1st Thu.	6:15	Oct.-May††	City Club	E. A. Halbach, 2971 S. 52 St.
MOLINE, ILL.	Pop. Ast. Club	Wed.†††	7:30	Feb.-Nov.	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	New Haven A.A.S.	4th Sat.	8:00	Sept.-June	Yale Obs.	I. J. Neale, 29 Fairmont Ave.
NEW ORLEANS	A.S. of N. Orleans	Last Wed.	8:00	Sept.-May	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
NEW YORK	*A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
"	Junior Ast. Club	1st, 3rd Fri.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORFOLK, VA.	A.A.S. of Norfolk	2nd Thu.	8:00	All year	635 W. 29th St.	P. N. Anderson, 635 W. 29th St.
NORWALK, CAL.	Excelsior Tel. Club	Thu.	7:00	All year	Excelsior Union H. S.	Geo. F. Joyner, 410 Sproul St.
NORWALK, CONN.	Norwalk Ast. Soc.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-5947
OAKLAND, CAL.	Eastbay A.A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. of F.I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	*Rittenhouse A.S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	*A.A.A. of P'burgh	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. B'er, 837 Estella St.
PONTIAC, MICH.	*Pontiac A.A.A.	2nd Thu.	8:00	All year	Private homes	Harvey E. Orser, 34 Pine St.
PORTLAND, ME.	A.S. of Maine	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	*Ast. Study Group	1st Wed.	8:00	All year	No. 9 Pacific Bldg.	H. J. Carruthers, 427 S. 61 Ave.
PROVIDENCE, R.I.	Skyscrapers, Inc.	Mon. or Wed.	8:00	All year	Ladd Observatory	Ladd Obs., Brown U., *GA.* 1633
RENO, NEV.	A.S. of Nev.	4th Wed.	8:00	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	Roch. Ast. Club	Alt. Fri.	8:00	Oct.-May	Univ. of Rochester	M. L. Groff, 400 University Ave.
SAN DIEGO, CAL.	Ast. Soc. of S. D.	1st Fri.	7:30	Oct.-June	504 Elec. Bldg.	R. M. Lippert, Box 41, N. Park Sta.
SCHENECTADY	S'tady Ast. Club	Meetings suspended				C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	St. Joseph Val. Ast.	Last Tue.	8:00	All year	928 Oak St.	F. K. Czyzewski, South Bend Tribune
TACOMA, WASH.	Tacoma A.A.	Meetings suspended				Grant Burke, Route 3, Box 349
TULSA, OKLA.	Tulsa A.S.	Occasional meetings				V. L. Jones, 4-8462
WASHINGTON, D.C.	Nat'l. Cap. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Miss D. Harris, 1621 T St., N.W., *Du.* 4200
WICHITA, KANS.	*Wichita A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
WORCESTER, Mass.	*Aldrich Ast. Club	2nd Tue.	7:30	All year	Mus. Natural History	W. C. Lovell, 158 Austin, 31559
YAKIMA, WASH.	Yak. Am. Astr'mers	3rd Tue.	7:30	All year	Chamb. of Comm. Bldg.	C. A. Zumwalt, 1019 Pleasant

†June, Jul., Aug., City parks ††Dinner meeting †††Nearest 1st-quarter moon

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *January*, WINTER SKY PICTURES. (See page 6.)

This month visitors to the planetarium have an opportunity to renew their acquaintance with the winter constellations, of such outstanding beauty and interest. Simple methods are shown for locating the stars of Orion, Taurus, and Canis Major, and the other bright stars which stud the sparkling skies of winter. Ancient constellation pictures appear in the planetarium heavens, and we find that some of these old figures are helpful devices for remembering the positions of stars.

★ **THE HAYDEN PLANETARIUM** presents in *January*, UNDER THE WINTER SKY. (See page 6.)

In *February*, TRIP AROUND THE WORLD. All aboard for points north and south! This Trip Around the World is completed in less than one hour, but by the time you come back home you will have seen the stars slowly circling parallel to the horizon at the north pole, you will have seen the midnight sun, the Southern Cross, the stars that shine over our boys wherever they are. While we watch the changing scene below us we keep an astronomical eye on the ever-changing constellations as we travel over the great hill of the earth.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays ..... 3 and 8:30 p.m.
Sundays and Holidays ..... 3, 4, and 8:30 p.m.

★ STAFF—*Director*, Arthur L. Draper: *Lecturer*, Nicholas E. Wagman; *Manager*, Frank S. McGary; *Public Relations*, John F. Landis; *Chief Instructor of Navigation*, Fitz-Hugh Marshall, Jr.: *Instructor, School of Navigation*, Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ..... 2, 3:30, and 8:30 p.m.
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Associate Curator*, Marian Lockwood; *Assistant Curator*, Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant*, Fred Raiser; *Lecturers*, Charles O. Roth, Jr., Shirley I. Gale, John Saunders.